SUPPLEMENT

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Section V.—Preventive Medicine and Tropical Hygiene.

(Continued.)

PREPARATION OF DIPHTHERIA ANTITOXIN.

By F. G. Morgan, M.B., Ch.B. (Melbourne),
Commonwealth Serum Laboratories.

The object of this paper is to sketch briefly the outlines of the preparation of diphtheria antitoxic serum which is the main therapeutic agent in the treatment of diphtheria. I have been asked to refer to the routine bacteriological diagnosis of this disease.

The main clinical conditions to be differentiated from diphtheria are follicular tonsillitis due to streptococci or other organisms not the *Bacillus diphtheriae,* Vincent's angina and secondary syphilitic ulceration. If suspicion exists that the case is diphtheria, antitoxin should be given without waiting for the results of bacteriological diagnosis, for failure to discover diphtheria bacilli from a throat swab does not necessarily mean that the case is not diphtheria. Valuable time will not be wasted therefore in waiting for the bacteriological findings.

Bacteriological Diagnosis.

Swabs are made from both the nose and throat and preferably from the lesion itself. The swab is then smeared over the surface of an inspissated serum slope. The cultures should be placed after as little delay as possible in the incubator at 37° C. for twelve to eighteen hours. If the culture be kept too long at room temperature, the associated bacteria may outgrow the *Bacillus diphtheriae.* At the time of making cultures smears may be made directly from the swab upon glass slides and stained with Löffler's blue. These smears may show the presence of bacteria resembling *Bacillus diptheriae* morphologically. Failing the presence of *Bacillus diphtheriae,* the organisms characteristic of Vincent's angina, namely elongated fusiform bacilli and spirochaetes, may be demonstrated.

For the complete identification of the *Bacillus diphtheriae* isolation in pure culture of the organism is necessary. The strain should then be identified by means of virulence tests upon guinea pigs and the protective effect of diphtheria antitoxin used to demonstrate the specificity of the organism under test. A complete identification of the bacillus occupies considerable time; though there are numerous pitfalls connected with the identification of the diphtheria bacillus by morphology alone, for practical purposes this is resorted to in most cases. A smear is made from the twelve to eighteen hours' culture on inspissated serum. If the smear contains bacteria with the characteristic morphology of the diphtheria bacillus, the case may be reported as diphtheria. The morphology of the diphtheria bacillus is so varied that it is impossible to diagnose diphtheria on morphology alone. Further examination may prove an organism diagnosed as diphtheria on this ground to be avirulent or else to be one of the numerous diphtheroid bacilli.

Preparation of Antitoxin.

Preparation of Toxin.

The first step is the preparation of diphtheria toxin of high potency which will stimulate the production of antitoxins in an inoculated animal, the serum of which will then protect human beings and experiment animals against the *Bacillus diphtheriae* and its toxins. This toxin is formed in a suitable broth when the *Bacillus diphtheriae* is grown upon it under correct conditions. Many factors enter into the production of a good diphtheria toxin for immunization purposes. Of paramount importance are the selection of a strain of diphtheria bacilli capable of producing a powerful toxin, the preparation of a suitable medium and conditions for growth and the harvesting of the toxin at the time of its maximum developement in the medium. Strains of diphtheria bacilli which are highly virulent towards animals, are not necessarily good producers of toxin, though as a general rule the most virulent bacilli produce the strongest toxins. Park and Williams's No. 8 strain was isolated from a mild case of tonsillar diphtheria. It is now used over the whole world in the preparation of diphtheria toxin.

Much care and attention to detail must be exercised in the preparation of the broth medium for the growth of the germ. Several different methods of preparing diphtheria broth are employed with successful results in toxin production in different parts of the world, but time does not permit of discussion. It is necessary to insure an abundant supply of air to the growing organisms to obtain a free growth of toxin. Therefore the containers are so shaped that a large surface area of broth is presented to the air. The broth is placed in separate containers and care is exercised that an optimum depth of fluid should not be exceeded. The containers are inoculated from a separate seed flask which has been incubated overnight, and they are then placed in the incubator at 36° C.

to grow. The bacilli form a thick film across the surface. Care must be exercised not to shake or disturb the containers, for if the film is broken the rate of toxin production is interfered with.

When the amount of toxin produced has reached its maximum which usually occurs within eight or ten days, the inoculated broth is removed from the incubator. It is then filtered through porcelain candles to remove the living organisms. The toxic broth is then placed in large bottles in cold storage until it can be estimated for potency. Toxin is deleteriously affected by light, heat and other agents. This has an important bearing upon diphtheria toxin which is used for the Schick reaction. The strength of the toxic broth is estimated by means of animal inoculation. Its strength is expressed in terms of a fraction of a cubic centimetre required to kill a guinea pig weighing 250 grammes in ninety-six hours.

Possessing a toxin of known strength we are now in a position to undertake the immunization of animals which are to yield antitoxic serum.

Immunization.

Horses are the animals usually selected for they develope a high degree of immunity, yield a large volume of serum and are tractable. Healthy young animals respond better to immunization than aged or otherwise unsound animals. Immunization is begun with a very small dose which is approximately 0.01 cubic centimetre. This dose is injected intramuscularly with a syringe and is repeated every third or fourth day with gradually increasing doses, until as much as a litre of toxin may be given. From time to time samples of blood are removed from the animal and tested upon guinea pigs to determine the unitage. When the horse has developed a sufficient number of units per cubic centimetre in its blood, it is prepared for bleeding. There is a considerable variation amongst horses in their response to immunization. Some give excellent high grade antitoxin for a number of months or even years; others fail to yield serum of any value. Before bleeding the neck is shaved and the skin cleansed with antiseptic. The horse is led into a crush and the jugular vein is pierced with a sharp pointed cannula. To the cannula is attached a sterile rubber tube which is connected with a bottle in which the blood is collected. These bottles contain a small amount of potassium oxalate solution which prevents clotting of the freshly drawn blood.

On an average ten litres of blood are removed from each horse at a bleeding. This is repeated two or three times at intervals of three or four days. The animal is then turned out to rest for several weeks before re-immunizing.

The fresh blood is allowed to stand at 37° C. until the corpuscles have settled to the bottom in a thick layer. The clear fluid (plasma) is then drawn off into other bottles. The blood corpuscles from a single horse are then collected together and returned to the veins of the horse from which they were drawn a few hours previously. This method of returning the blood corpuscles was designed by Dr. W. J. Penfold, Director of the Commonwealth Serum Laboratories, and by this means much more frequent and extensive bleedings can be made than is the case where this portion of the blood is discarded.

Treatment of the Plasma.

The immune plasma is now treated in one of two ways, according to whether it is to be used for making unconcentrated or concentrated diphtheria antitoxic serum.

(a) *Unconcentrated Serum.* The plasma is run into large clotting jars and calcium chloride solution is added to remove the potassium oxalate which was mixed with the blood in the bleeding bottles. There is a rapid formation of clot, consisting of fibrin which gradually sinks to the bottom. Weights are placed upon the upper surface of the clot to aid the separation of the clot from the serum.

In the jars there is now a thick, tough lump of yellowish-white clot and a pale straw-coloured limpid fluid known as serum. The latter is collected into suitably stoppered two-litre bottles and 0.35% tricresol is added as a preservative.

(b) *Concentrated Serum.* In the process of concentration antitoxic plasma is treated on a large scale in the biochemical laboratory. By a series of manipulations involving successive precipitations and filtrations of the serum proteins, a large proportion of the globulin fraction and the whole of the albumin fraction is eliminated. The resulting protein solution consists for the most part of a solution of the serum pseudo-globulin to which the antitoxin is attached.

This concentrated serum is a clear limpid non-toxic product, of relatively low protein content and contains in small bulk many thousands of antitoxin units.

A preservative (0.35% tricresol) is added to the serum which is subsequently treated in the same fashion as the unconcentrated product.

Filtration.

In order to render the serum bacteriologically sterile, it is passed through fine porcelain filters, the pores of which are too small to permit the passage of bacteria. The serum is collected into a large stock bottle from which ampoules are filled in the process of bottling.

Testing the Potency of Antitoxic Serum.

Samples are removed from the stock bottle and tested for unitage by means of animal inoculations. The unitage is estimated by comparison with the standard antitoxin issued from the Hygienic Laboratory, Washington, United States of America.

Tests for sterility are performed upon samples taken from the stock bottle. These samples are obtained at the commencement and at the end of the bottling operation. When bottled and packed the finished products are then placed in cold storage at 6.6° C. to await issue.

THE PREVENTION OF DIPHTHERIA.

By D. L. Barlow, M.D., B.S. (Adelaide),
Honorary Clinical Pathologist, Adelaide Hospital,
and
G. H. Burnell, M.D., B.S. (Adelaide),
Adelaide.

It is universally admitted that the problem of the prevention of diphtheria has been narrowed down to the detection and treatment of human carriers of the disease, the other factors in its spread being entirely subsidiary in importance to the human one.

Since the discovery of the causative organism by Klebs and Löffler in 1883 and 1884 progress in the prevention of the disease has not been as rapid as one could wish. Indeed recent statistics of the Commonwealth have shown that we are at a stand-still. It, therefore, behoves us to consider where our preventive methods have fallen short and how they can be improved.

In a disease so wide-spread as this the first consideration is that the methods adopted shall be practicable on a large scale and it has been our endeavour to find such a method. One of us in 1918 undertook the control of the disease in Broken Hill, which at that time was a city of over 30,000 population, and as far as any scientific control of diphtheria was concerned, was a virgin territory. Diphtheria had been epidemic in the city since 1913, as is shown in Table I.

TABLE I.

Year.	Cases.
1913	651
1914	589
1915	442
1916	522
1917	377
1918	322

There is no doubt that the figures from 1913 to 1917 undoubtedly include some cases that were not diphtheria, as in the absence of a laboratory from the city the practitioners had wisely adopted the practice of notifying all cases with membranous tonsillitis as diphtheria, but on the other hand it is equally probable that many mild cases of diphtheria were overlooked in the absence of a bacteriological examination. The only precaution that had been taken up to the time of opening the laboratory in 1917 was to keep the infected child in isolation for three weeks.

Between 1917 and 1918 no child was discharged from hospital until two consecutive swabs were obtained from which no bacilli could be found.

Table I. will show that some slight progress had been made since the opening of the laboratory, but this was of very small extent. In November, 1918, therefore, it was decided to take further steps. Owing to the comparative non-susceptibility of the adult population to the disease and to the greater accessibility of the school children for the application of preventive measures, the schools were naturally chosen as the point of attack. Between November, 1918, and March, 1919, 5,369 school children were examined, and fifty-two or approximately 1% was found to be harbouring bacilli morphologically indistinguishable from diphtheria bacilli. Of these 50% were boys and 50% were girls. Swabs were only taken from the throat in the great majority of cases, but where it was noted that the child had some excoriation of the skin around the nostrils or a nasal discharge, swabs were taken from the nose. Curiously enough no bacilli were found in any of the nasal swabbings, but one carrier after admission to hospital developed a nasal discharge containing diphtheria bacilli. One hundred and forty-three or 2.6% were noted as having large or diseased tonsils, but in only three or 2% of these were diphtheria bacilli obtained. Of twenty-nine of the carriers in whom the history was obtained, eight had had clinical diphtheria previously, the longest intervening period being four years and the shortest five months. In this same series of twenty-nine children, in the case of five another member of the family had had clinical diphtheria. In examining the swabs the diagnosis was made on morphological grounds alone. We are well aware that this will give rise to considerable discussion, but it must be remembered that detailed investigation would at least in this instance have rendered the scheme impracticable. In a previous note we have already emphasized the value of examining the swab at the end of forty-eight hours in the event of the first day's examination failing to discover diphtheria bacilli. We have also indicated the value of the toluidin blue method of staining in the recognition of diphtheria bacilli. It was decided in making a diagnosis to ignore all the solid types of bacilli and to accept only the granular type, either those with bi-polar granules or the barred granular type as diphtheria bacilli. Club formation was neglected, as experience had shown that in any film containing club forms careful search would reveal at least a few bacilli of the granular type. Clubs, therefore, only indicated the necessity of a specially detailed inspection of the smear. The practice of diagnosing the bacillus by its granules is supported by many investigators.

Kolmer and Moshage (1) says: "Experience has shown that the majority of beaded or granular and barred types of diphtheria bacilli are virulent, whereas the solid type, particularly the short solid variety are non-virulent, but between these extremes are many types, the virulence of which cannot be foretold with any degree of accuracy according to morphology alone."

Again, Debré, Letulle and Sergent (2) speaking of the value of the granules in the recognition of a virulent diphtheria bacillus state they have not yet found a strain of *Bacillus diphtheriae* in which the granules are entirely absent nor have they isolated a pseudo-bacillus in which the granules are present. With regard to the inoculation tests in establishing the virulence or non-virulence of a particular organism, it has been firmly held for many years that these tests are necessary, but latterly this has been called in question.

Besson (3) says: "It is not justifiable to assume that because a diphtheria bacillus is non-pathogenic to laboratory animals, that it is therefore non-pathogenic to man. On the other hand there is some evidence to show that 'non-virulent' diphtheria bacilli are capable of producing diphtheria in a susceptible human subject."

Again, Topley (4) says: "When we state that an organism is pathogenic for laboratory animals, there is no necessary implication that it can produce disease under natural conditions."

Graham Smith showed that the virulence of a diphtheria culture depends on the age of the guinea pig used and also that the first sub-cultures in broth are often non-virulent, but that if the culture be repeated in broth several times before inoculation, it will prove to be highly virulent. He also showed that different litters of guinea pigs manifested marked differences in susceptibility and

concludes by quoting Theobald Smith thus: "The large amount of labour which has been expended in comparing the virulence of diphtheria bacilli from different sources, is all but wasted."

Finally, Arkwright (6) was able to produce a decided increase of antitoxin in the blood serum of a horse after inoculation with filtrates from cultures of non-virulent *Bacillus diphtheriae*, the actual increase being from one-quarter unit per cubic centimetre to twenty-five units per cubic centimetre. He concludes: "There is some striking evidence of the excessive frequency of non-virulent *Bacillus diphtheriae* in contacts and convalescents in some outbreaks and even of the occasional association of non-virulent *Bacillus diphtheriae* with clinical diphtheria. It is, therefore, probable that the causal connexion between carriers of non-virulent *Bacillus diphtheriae* and clinical diphtheria cannot be neglected, although the non-virulent strains are possibly of less importance."

Treatment of Carriers.

As already stated fifty-one of the fifty-two children were admitted to hospital for isolation, the other being an only child and well isolated at home. This result was largely brought about by the tact and persuasion of the City Sanitary Inspectress, Mrs. Allen. They were allowed to mix with convalescent diphtheria patients in the play ground and, as already stated, none of them developed diphtheria although one developed a nasal discharge in which diphtheria bacilli were found. Many of them cleared up spontaneously, thus confirming an opinion held by us for some time, that many school carriers only "carry" for a few days. The remainder who did not clear up rapidly, were treated at first by frequent spraying of the throat with an atomiser. For this purpose various solutions were used, most commonly "Eusol" and zinc sulphate 1% to 2%. Although by these means, or perhaps independently of them these infections all cleared up, we have in some convalescent carriers found considerable difficulty in achieving this result and we will digress for a moment to discuss the treatment of these refractory cases.

The following methods were tried: (i.) Massive doses of antitoxin subcutaneously. This was soon abandoned as useless. (ii.) Spraying with "Eusol" and zinc sulphate solutions. These were successful in some cases, but signally failed in others. (iii.) Spraying the nose and throat with antitoxin. This had no effect. (iv.) Spraying with live cultures of staphylococci. This method although highly recommended by some, is absolutely useless, but it is apparently not dangerous. (v.) Autogenous and heterogeneous vaccines of diphtheria bacilli given subcutaneously.

Walton (7) described in 1910 the case of a carrier who cleared up after two injections of a vaccine composed of diphtheria bacilli and staphylococci. Since then several writers have recorded patients so treated, but after a lengthy trial we abandoned vaccines as they yielded no improvement on previous results. One case was that of a woman who had been admitted to hospital with clinical diphtheria and received one hundred million bacilli of a heterogeneous vaccine. Six weeks after discharge she returned to hospital with a fresh patch of membrane on her tonsils from which the diphtheria bacillus was obtained. It is obvious that a patient may be immune to the constitutional effects of the bacillus and may yet have only little local resistance to the organism in the faucial tissue.

This is, of course, the case in carriers who almost uniformly fail to yield a Schick reaction. It is, therefore, obvious that no improvement in treatment of carriers can be hoped for in the direction of increasing the patient's general resistance and that local treatment will be more valuable. We note however that Brownlie (8) claims considerable success in a series of fifty carriers.

Although local antitoxin sprays had been found valueless, it was decided to try the effect of an antibacterial serum which was made as follows.

A culture of virulent diphtheria bacilli was made and injected into the laboratory Sister, Miss Cook, who volunteered for this purpose. The initial dose was twenty-five millions and was rapidly increased to five hundred millions at which stage the sister's serum strongly agglutinated a culture of the bacillus, but the dosage was increased until two thousand millions was reached. Several hundred cubic centimetres of blood were then withdrawn and the serum collected and 1% phenol added as a preservative. This was known to contain one class of antibodies, that is, agglutinins. Lister, of South Africa has shown that with pneumococci agglutination may be taken as a fair criterion of the formation of immune bodies. This serum was used on seven convalescent carriers, being sprayed in the throat night and morning with an atomiser. Six of the seven cleared up rapidly.

Although this method was independently evolved, a somewhat similar method had been already devised elsewhere. Thus Benard (9) has treated carriers by insufflating three or four times a day a powder composed of dried anti-diphtheria bacillary serum, "Novarsenobenzol" and bismuth carbonate for which he claimed much more efficiency in rendering the nasal passages free of bacilli than could be obtained by any other method. We are convinced that this method will be of value especially in nasal cases where surgical measures cannot so readily be put into operation and it is hoped that it will be possible for the Commonwealth Serum Laboratory to undertake the manufacture of the serum. It must be noted that this problem will remain with us, even when active immunization with toxin-antitoxin mixtures is a general practice, since as has been already stated the constitutional resistance to diphtheria toxin bears very little relation to the resistance of the faucial tissues to the existence of the diphtheria bacillus.

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REPORT ON CAMPAIGN AGAINST DIPHTHERIA: BENDIGO, 1923.

By K. R. Moore, M.B., Ch.B. (Melbourne),
Medical Officer, Commonwealth Health Laboratory, Bendigo.

A campaign against diphtheria was conducted in Bendigo and the Borough of Eaglehawk, as well as the Shires of Marong, Strathfieldsaye and Huntley, among the school-children commencing in February, 1923.

The campaign was initiated under the auspices of the various district health officers and the working can be divided into two sections.

Swabbing Campaign.

Nose and throat swabs were taken from every school-child and teacher at the rate of about two hundred *per diem*. Inspissated serum tubes were inoculated on the spot and were delivered to the Commonwealth Health Laboratory, Bendigo, in the afternoon. There they were incubated overnight and were examined the following day. Carriers were re-swabbed once a week and were kept in isolation as well as being instructed how to douche the nose and gargle the throat. Virulence tests were done on the bacilli of carriers.

In all 7,174 children and teachers were swabbed. Of these one hundred and three were known to be teachers, but the incomplete records in some instances did not permit accuracy in this report.

Of the total 3,322 were males and 3,342 females; in 510 instances sex was not stated.

Six hundred and ninety-six carriers were detected of an average of 8.9 years; the percentage of carriers is thus 9.69. Three hundred and fifty-three or 10.62% of males were carriers and two hundred and eighty or 8.38% of females. Of one hundred and three teachers, fifteen or 14.5% were carriers.

The age-incidence of carriers showed that the percentage-curve remains fairly constantly at 8% to 10% up to the age of ten years and for both sexes. From that age onwards the percentage decreases, till at fifteen 3.5% only of males and no females were found to be carriers. The high percentage of carriers among teachers is noteworthy in relation to this observation.

Period of Carrier Condition.

Of 696 carriers from 292 one swab only from which diphtheria bacilli were found, was obtained, while from 151 two such swabs, from seventy three such swabs, from forty four such swabs, from eleven five such swabs, from eight six such swabs, from three seven such swabs, and from one eight such swabs were obtained. In 120 cases the records were incomplete on this point.

Re-swabbing was performed each week and carriers were released from quarantine after two consecutive swabbings from which no bacilli were found, had been obtained. Thus, in the great majority the condition was cleared up in three to four weeks.

Location of Bacilli.

In 227 carriers bacilli were found in the nose in only 105 or 46%; the bacilli were found in the throat only of fifty-one persons or 22% and in seventy-one the bacilli were found in both nose and throat, equivalent to between 32% and 33%. These figures are taken from carriers of at least a week's standing.

Distribution of Carriers.

Table I.

District	No. of Swabs	No. of Carriers	Percentage
Bendigo	5087	518	10.1
Eaglehawk	832	94	11.3
Marong	296	17	5.7
Strathfieldsaye	339	19	5.6
Huntley	621	48	7.7
All Districts	7174	696	9.69

Influence of Proximity in School and Home.

It was noticed during the examination of swabs that proximity in class was an important factor in disseminating the carrier condition and, also that frequently several members of the same family were carriers at the same time. This is taken to indicate the probability of home contact being an important factor in this relation also.

Throat Conditions in Carriers.

The throats of two hundred and fourteen carriers were inspected; the results are given in Table II.

Table II.

Throat Condition	Number	Percentage
Greatly enlarged tonsils	48	22.4
Slightly enlarged tonsils	104	48.6
Engorgement, enlarged uvula, and other minor defects	33	15.4
All throat conditions	185	86.4

Thus the proportion of carriers affected is very high and the probability that throat defects especially enlarged and inflamed tonsils exert a large influence in determining the carrier condition, is very great.

Inspection of the figures of notification of clinical diphtheria for Bendigo for the last five years, show that the years 1920 and 1921 were marked by epidemics of the disease. A swabbing campaign inaugurated in 1922 was followed by a definite drop in the number of notifications, which has continued since.

In Table III. the numbers of notifications (quarterly) of Bendigo and Ballarat during the last five years are compared.

TABLE III.

Year	Quarter	Notifications in Bendigo	Notifications in Ballarat
1919	First	27	13
	Second	23	7
	Third	26	25
	Fourth	16	18
1920	First	96	46
	Second	135	160
	Third	75	72
	Fourth	44	52
1921	First	66	19
	Second	277	174
	Third	83	41
	Fourth	43	28
1922	First	93	31
	Second	76	46
	Third	24	23
	Fourth	3	11
1923	First	33	28
	Second	17	23

The first six months of each year taken together read as follows: Bendigo: 50, 231, 343, 171 and 50; Ballarat: 20, 206, 243, 77 and 51. These figures show that the decrease for Bendigo in 1923 is proportionately very much greater than for Ballarat.

Further than this, during the month of August, 1923, no cases of diphtheria were reported in Bendigo or Eaglehawk and the diphtheria ward in the Bendigo Hospital remained empty for three weeks. The longest time it had remained empty prior to that was for two hours some years ago.

Virulence Tests.

Virulence tests were conducted on as many strains as possible isolated from the carriers. Many difficulties were encountered in this branch of the work owing to the necessity for attempting to keep pace with the swabbing.

The method of testing adopted was originally that of Force and Beatty (*American Journal of Hygiene*, September, 1922), but many modifications were introduced to meet special circumstances.

In all one hundred and fifty-eight tests were performed and one hundred and twenty definite readings obtained. Of these fifty-one showed positive virulence (42.5%) and the remaining sixty-nine strains were avirulent.

Table IV. is of interest.

TABLE IV.

Source of Strain	Number of Tests	Incomplete Tests	Virulent Bacilli	Percentage Virulent
Both throat and nose	101	20	42	51.9
Nose only	40	11	3	11.5
Throat only	17	7	6	60.0

In view of the figures quoted earlier showing that a large percentage of carriers harboured bacilli in the nose only after one week of treatment, the extremely low virulence percentage of nasal strains is noteworthy.

Schick Test.

Volunteers were asked for among the school-children for the Schick test and active immunization process, following a vigorous campaign aided by the local newspapers and school masters.

From 5,761 children, representing the school population at the time of Bendigo and Eaglehawk, 1,616 or 28% gained the consent of their parents in writing to have the process performed on them.

Preparation.

The toxin was diluted freshly each day and a control in the shape of the toxin of the same dilution heated to 75° C. for ten minutes was used in the left arm. This control is necessary for the detection of pseudo-reactions. The arms were inspected on the fourth and tenth days after the performance of the test.

Positive reactions were arbitrarily divided into "+," "$\pm$" and "$\overline{+}$," according to the severity of the reaction. No trouble was experienced in handling the children, who did not complain of pain.

Results.

TABLE V.

Number Tested	Incomplete	Reacted				
		+	$\pm$	$\overline{+}$	Total	Percentage
1616	35	390	177	158	725	45.9

One hundred and sixty-one pseudo-reactions were observed equalling 9.9%.

The average age of the children was 9.3 years.

Age Incidence.

TABLE VI.

Result of Test	Ages														
	Under 4	4	5	6	7	8	9	10	11	12	13	14	Over 14	Unknown	Total
+	4	6	20	53	48	54	60	32	43	33	16	5	1	8	383
$\pm$	2	1	17	16	20	16	18	15	21	12	19	1	2	4	164
$\overline{+}$	1	—	9	14	10	13	26	14	21	17	18	6	5	—	154
Total +	7	7	46	83	78	83	104	61	85	62	53	12	8	12	701
"Negative"	3	9	23	58	88	97	82	87	117	95	65	23	31	14	792
Totals	10	16	69	141	166	180	186	148	202	157	118	35	39	26	1493

This series does not include eighty-eight children from St. Aidan's Orphanage who had been previously tested and partially immunized.

The age-incidence percentage curve when plotted, coincides fairly closely with the figures of Schick and Park, ranging from 70% positive at under four to 20% at fourteen years and over.

Influence of Consanguinity.

A strong tendency for children of the same family to yield the same type of reaction was noticed, although out of three sets of twins in two instances one reacted to the test while the other did not give a reaction.

Previous History of Diphtheria.

Of three hundred and two children who gave a previous history of having had diphtheria on one or more occasions, one hundred and thirty or 43% were "Schick-positive." Thus the idea that an attack of diphtheria confers little or no immunity of a lasting nature is strengthened.

Reactions of Carriers.

Of one hundred and forty-seven children who had been carriers during 1922 or 1923, sixty-three or 43.8% were "Schick-positive."

A search through the records of the campaign revealed that in two instances "Schick-positive" children were proved to be carriers of virulent bacilli. In all other instances when carriers were submitted to the Schick test and when a virulence test was performed on their bacilli, in the event of the child being "Schick-positive," the bacilli were found to be avirulent; conversely, if the bacilli were virulent, the child did not react to the Schick test. In neither of the cases mentioned did the child subsequently develope diphtheria.

Active Immunization Process.

All children available who showed any grade of positive reaction, were subjected to the active immunization process, by means of three injections at weekly intervals of 0.125, 0.5 and one cubic centimetre respectively of toxin-antitoxin mixture, obtained from the Commonwealth Serum Laboratories.

Out of 725 "positives" ten refused to continue and forty-two were absent on the occasions of all the injections.

Of the remaining six hundred and seventy-three, five hundred and seventy-nine or 87% of the total received the full course of three injections; sixty-three (8.7%) received two and thirty-one received one injection only.

Testing of Immunity.

This was done two months after the final immunizing dose by means of a further Schick test.

Immunity is said to develope throughout six months, but this period would have clashed with the Christmas vacation; consequently, the minimum period recommended was chosen in the interests of expedition and also to reduce to a minimum the number of "objecting" parents, by keeping the matter before their notice. Children who had only received one immunizing dose, were not re-tested.

Of the six hundred and forty-two who received either three or two injections, sixty-one were either absent or their parents objected to the final test.

Of the remaining five hundred and eighty-one, five hundred and thirty-three had received the full course of three injections and forty-eight had received the first two.

On reading the results no case of a full positive, (+), reaction was observed and altogether nearly 90% of the children showed either no reaction at all or a very faint one.

The results are given in Table VII.

TABLE VII.

Number of Injections	Result				Absentees
	No Reaction	Reaction			
		$\overset{+}{=}$	$\overset{+}{-}$	+	
Three	304	176	53	0	46
Two	30	12	6	0	15
Total	334	188	59	0	61

To obtain the significance of these figures the reactions expressed in percentages are given before and after immunization, side by side:

Before immunization.	*After immunization.*
$\overset{+}{=}$ = 24.74%	= nil
$\overset{+}{-}$ = 11.19%	= 4.1%
+ = 9.99%	= 13.1%
Total Reaction = 45.92%	= 17.2%
No reaction = 54.08%	= 82.8%

An inspection of the records revealed that of five hundred and thirty-three children receiving the full course of injections only twenty-five or 4.7%, failed to show a reduction in the strength of reaction two months later and also that all but six, or 12.5% of the forty-eight receiving two injections only showed a similar reduction. It is considered likely that as the bulk of reactions classed as "$\overset{+}{=}$" were exceedingly faint, if a further series of tests had been done at the expiration of six months, 95% or more would have yielded no reaction.

It may reasonably be assumed that of all the school-children of Bendigo and Eaglehawk one-fourth of those naturally susceptible to diphtheria can now claim to be immune from it. Up to the time of writing no child who was shown not to react to the Schick test, and no susceptible child who received the full immunizing course, has had diphtheria, although in two cases such children have suffered from follicular tonsillitis with proved avirulent Klebs-Löffler bacilli in the swabs.

THE SCHICK REACTION IN COUNTRY SCHOOLS IN NEW SOUTH WALES.

By EUSTACE WILLIAM FERGUSON, M.B., CH.M. (Sydney),
Principal Microbiologist, Department of Public Health, New South Wales,
and
ERNEST LESLIE MORGAN, M.B., CH.M. (Sydney),
Assistant Microbiologist, Department of Public Health, New South Wales.

DURING recent years the late summer and autumn have been marked by outbreaks of diphtheria of more or less seriousness in country towns in New South Wales. Appearing as it does mostly among the children of school

age, an outbreak of diphtheria in a town if it reaches serious dimensions, almost always involves the wholesale swabbing of the school children and it may be in rare instances the closing of the school.

Attention was directed to the Schick test not as affording a means of detecting carriers or person actually affected with diphtheria, but as a mode of procedure for limiting the incidence of the disease by the discovery of the susceptible children with their subsequent immunization by toxin-antitoxin inoculation.

It had been hoped to try the Schick test on one of the larger country schools in 1922, but the presence of plague in Sydney prevented the Department from proceeding with the undertaking. It was decided, however, if possible to make an attempt in 1923 and Forbes was selected as a suitable town for the investigations. Two main reasons actuated the Department in deciding upon Forbes; one was that Forbes was among the towns with the highest number of cases of diphtheria in 1922 and the other was that the local council had in the past cooperated very satisfactorily with the Department in regard to anti-typhoid inoculations and it was thought that they would be willing to cooperate in the matter of diphtheria control.

The Forbes Municipal Council promptly agreed to assist the Department and arranged to obtain the necessary consent from the parents of as many of the school children as possible.

In the meantime the Parkes Municipal Council had approached the Department in regard to diphtheria control and arrangements were made to carry out the Schick test there as well as at Forbes.

These two towns are about twenty miles apart and are situated in the central district of New South Wales. While Parkes is among the foothills of the western slopes, Forbes is set practically on the edge of the great western plains. Around Parkes there is much closer settlement with many small farmers, while around Forbes the holdings are larger. In both cases, however, the children to be tested were for the most part town children and the conditions as regards the susceptibility to diphtheria were not considered to be far different. Furthermore, both towns are typical examples of country towns of the average size with a population of under ten thousand. Hence it was considered that any results obtained from these investigations as regards the susceptibility to diphtheria would be applicable to a large number of other towns in New South Wales.

The actual investigations were commenced on April 16 at Forbes, when one hundred and sixty-six children were inoculated at the State School and forty-three at the Convent School. On April 17 twenty-nine children were tested at the State School at Bedgerebong, twenty-one miles from Forbes on the Lachlan River. On April 18 the forty-eight hour readings were taken of the children inoculated at Forbes and the party proceeded to Parkes that night. On April 19, two hundred and eighty children were tested at the State School, Parkes, and fifty-six at the Convent School. On April 20 one officer remained at Parkes and took the 24-hour readings, while the other proceeded back to Forbes and out to Bedgerebong where the 72-hour readings were taken, returning to Forbes to take the 96-hour readings in the afternoon. No readings could be taken on Saturday or Sunday, but on Monday, April 23, the 168-hour readings were taken at Forbes and the 96-hour readings at Parkes, while on April 24 all the positive and doubtful reactions at Parkes were reviewed by both officers. Final readings at Bedgerebong were taken by a medical officer of the Education Department on April 24.

The party consisted of two medical officers and a laboratory assistant. This enabled the work to be carried out more expeditiously and efficiently. The assistant was charged with the duties of sterilizing the salt solution, syringes, needles, *et cetera* and in helping with the dilution of the toxin. He also prepared the arms for inoculation. The two medical officers inoculated concurrently, one in the right arm using unheated toxin and the other in the left arm with heated toxin. The procedure halved the time that would have been necessary had one officer been required to perform both injections. All injections were, of course, made intracutaneously and little difficulty was experienced in arriving at the correct depth. Very little trouble was experienced with the children, even quite young children submitting willingly to the inoculation.

The toxin used was prepared by the Commonwealth Serum Laboratories and was supplied in phials containing one cubic centimetre, the guinea pig minimal lethal dose being 0.028 cubic centimetre. The amount inoculated was 0.025 minimum lethal dose contained in 0.2 cubic centimetres of saline solution. As diluted toxin will not keep beyond about twenty-four hours, it was necessary to make the dilutions in the country. This involved taking considerable quantities of saline solution, but a convenient method was worked out which considerably minimized the labour and danger of contamination. The saline solution was put up into thirty cubic centimetre rubber corked bottles, twenty-eight cubic centimetres of sterile physiological saline solution being contained in each. For making the correct dilution all that was necessary was to remove 0.1 cubic centimetre of saline solution and replace it with 0.1 cubic centimetre of the undiluted toxin; this gave the necessary dilution of 0.025 minimum lethal dose in 0.2 cubic centimetre. In practice it was not considered necessary to remove the initial 0.1 cubic centimetre of saline solution as the error in dilution was so minute and the dilutions were therefore made by adding 0.1 cubic centimetre of toxin to each bottle of twenty-eight cubic centimetres. Of every two bottles of diluted toxin thus prepared, one was heated to destroy the toxin. It is recommended that the toxin to be treated should be subjected to a temperature of 75° C. for ten minutes; in these investigations, however, the method used by Dr. Marjorie Ross, at the Royal Alexandra Hospital for Children, Sydney, was adopted. In this method the diluted toxin is placed in a water bath and brought to boiling point. This procedure proved quite satisfactory, no Schick reactions manifesting themselves on the arms injected with the heated toxin, while pseudo-reactions were not affected.

The prepared bottles of diluted toxin were covered with rubber caps which were readily pierced by the needle of the syringe when required. One cubic centimetre "Record" syringes were used with platinum-iridium needles.

The work of marshalling the children and checking the names was entrusted to the school authorities who in conjunction with the sanitary inspectors at the two towns

rendered very valuable assistance to the investigation. With everything in readiness and the procedure fixed it was possible to inject large numbers of children in a comparatively short time. On the average about sixty children could be inoculated in an hour.

Readings.

Owing to the distance separating the two towns it proved necessary to take the readings at different intervals. Experience showed that readings were valueless under forty-eight hours; at twenty-four hours the true Schick positive reactions had not appeared, but there were a high number of evanescent flushings of the nature of pseudo-reactions. At forty-eight hours both the true and pseudo-reactions were well marked. At ninety-six the pseudo-reactions had faded or were fading in the majority of cases, while the true reactions were well marked. At the end of the week the true reactions were more brown and had commenced to scale, though one or two reactions classed as positive at ninety-six hours had practically faded at the end of the week.

Results.

Forbes State School.

Of the one hundred and sixty-six children inoculated thirty-two gave a positive reaction, two a reaction which was classified as doubtful and in two cases no readings could be obtained. The doubtful cases will be discussed later.

Forbes Convent School.

Forty-three children were inoculated; ten yielded positive reactions and one a doubtful reaction.

Bedgerebong State School.

Twenty-nine children were inoculated; seven yielded positive reactions.

Parkes State School.

Two hundred and eighty children were inoculated; ninety-nine yielded positive and six doubtful reactions. Three children were not seen after the twenty-four hour reading, when one gave a positive reaction and one did not react; the third child gave a pseudo-reaction which may have been masking a positive. this case has been included among the doubtful results.

Parkes Convent School.

Fifty-six children were inoculated; seven yielded positive reactions.

Excluding the doubtful cases the following percentages of positive reactions were obtained.

Forbes State School	19.39%
Forbes Convent School	23.25%
Bedgerebong State School	24. 1%
Parkes State School	35.36%
Parkes Convent School	12. 5%

For the two districts the combined positive results give the following percentages:

Forbes	20.76%
Parkes	31. 5%

Doubtful Reactions.

In three instances at Forbes and in six instances at Parkes the reactions were regarded as doubtful. These reactions were as follows:

N.S., a male, aged fifteen, was examined at Forbes. A slight reaction was observed after ninety-six hours; it was indefinite in one week.

A.B., a female, aged ten, was also examined at Forbes. A distinct pseudo-reaction occurred; the reaction was more persistent on the right and was still red after eight days; scaling occurred on both arms. This was probably a true reaction masked by a severe pseudo-reaction. The child was subsequently injected with toxin-antitoxin mixture.

M.K., a female, aged twelve, was examined at Forbes. A definite reaction was seen in forty-eight hours; it was not seen at ninety-six hours and the reaction had faded at the end of a week. This child was also included among those inoculated with toxin-antitoxin.

C.S., a female, aged eleven, was examined at Parkes. She was not seen after twenty-four hours; at that time a pseudo-reaction was present with possibly an underlying positive reaction.

C.F., a female, aged eleven, examined at Parkes yielded a pseudo-reaction with possibly an underlying positive reaction.

A male, aged twelve, and a female, aged thirteen, gave faint reactions after ninety-six hours, while a male aged six and a female aged six gave slight reactions after ninety-six hours.

It is probable that the majority of these children should be classed among those giving positive results. The hours of observation at Parkes were not the most suitable, there being too long a gap in the readings between the 24-hour reading and the 96-hour readings; also it would have been better had the final readings been taken after a full weeks' interval. It will be noted, however, that seven out of these nine children were over the age of ten and the impression gained at the time of inspection was that these children had acquired some immunity which had, however, not reached its maximum developement.

Age Incidence.

The age groups are for the most part so small in numbers that reliable deductions are hardly possible. The numbers tested of each age of both the boys and the girls separately and combined, with the numbers of each showing a positive reaction are shown in Table I. Even taking the combined children of all the schools the number is too small to allow of the percentages being worked out for each age.

In the table two main age groups 6 to 10 and 11 to 15 are used.

TABLE I.

Age Group (Years)	Boys			Girls			Total		
	Number Tested	Number Reacting	Percentage Reacting	Number Tested	Number Reacting	Percentage Reacting	Number Tested	Number Reacting	Percentage Reacting
6 to 10	135	25	18.51	146	54	37.51	291	79	27.14
11 to 15	144	23	15.97	108	43	39.81	252	66	26.15

Tables showing the results of the Schick Test at the various ages of the children tested.

TABLE II.

Age Years	PARKES. Boys Tested	Boys Reacting	Girls Tested	Girls Reacting	Total Tested	Total Reacting	FORBES (including BEDGEREBONG). Boys Tested	Boys Reacting	Girls Tested	Girls Reacting	Total Tested	Total Reacting
5	5	1	8	4	13	5	.	.	2	1	2	1
6	1	4	18	10	30	14	4	2	4	2	8	4
7	10	5	7	2	17	7	4	2	9	6	13	8
8	10	3	25	11	35	14	18	1	15	4	33	5
9	12	4	16	9	28	13	24	.	18	4	42	4
10	25	4	11	1	36	5	16	.	23	5	39	5
11	20	3	20	8	40	11	24	2	14	6	38	8
12	18	3	14	5	32	8	17	3	8	2	25	5
13	24	5	17	10	41	15	15	0	13	5	28	5
14	16	4	7	4	23	8	3	0	5	2	8	2
15	6	3	5	1	11	4	3	0	5	0	8	0
16	2	1	2	1	4	2	1	0	2	1	3	1
17	.	.	1	.	1	.	.	.	.	.	.	.
19 to 22	.	.	.	.	.	.	2	1	1	.	3	1

TABLE III.

PARKES AND FORBES.

Age. Years	Boys Tested	Boys Reacting	Girls Tested	Girls Reacting	Total Tested	Total Reacting
5	5	1	10	5	15	6
6	16	6	22	12	38	18
7	14	7	16	8	40	15
8	28	4	40	15	68	19
9	36	4	34	13	70	17
10	41	4	34	6	75	10
11	44	5	34	14	78	19
12	33	6	22	7	55	13
13	39	5	30	15	69	20
14	19	4	12	6	31	10
15	9	3	10	1	19	4
16	3	1	4	2	7	3
17	.	.	1	.	1	.
19 to 22	2	1	1	.	3	1

Immunization of Susceptible Children.

Following on the result of the test representations were made to the councils of the two towns that immunization of the susceptibles should be undertaken. Arrangements in this direction were made and a number of children have been inoculated at each town with toxin-antitoxin mixture.

The trial investigations at Forbes and Parkes proved the readiness of the practical application of the test and it is intended to extend the operations to other towns, while with the gradual education of the public it may be possible in the future to secure the wholesale application of the Schick test.

THE ROLE OF THE PRACTITIONER IN THE CONTROL OF DIPHTHERIA.

By F. V. Scholes, M.D., D.P.H.,
Medical Superintendent, Queen Victoria Memorial Infectious Diseases Hospital, Fairfield, Victoria.

The subject of this paper was not a matter of personal choice, but was suggested by the Secretary of the Preventive Medicine Section of Congress. Having read three papers on this same topic within the space of two years, I feel a little diffidence in reiterating the same old statements, but the prevalence of diphtheria in Australia is a matter of great importance and an interchange of views on the means of its control can do nothing but good.

The number of cases occurring in Victoria and particularly in Melbourne jumped up suddenly in the autumn of 1910, then again in the autumn of 1911 and then rose fairly steadily with the usual seasonal fluctuations till it reached its maximum in 1918. Another sharp rise occurred in 1921, but generally there has been a decided fall since 1918. In view of the fact that this disease has raged apparently unchecked for the last thirteen years and is now subsiding apparently only in obedience to those unknown laws which have caused it to do so in the past and particularly in view of the fact that for all we know the case incidence next year or the year after may rise to a point hitherto unreached, one might be pardoned for thinking that medical effort has met with no success and that none is likely in the near future. Lest the general practitioner then conclude that he has done nothing and can do nothing, let me point out something that he has done during those thirteen years.

At the Medical Congress held at Sydney in 1911, I read a paper designed to show that as the great majority of cases of laryngeal diphtheria were secondary, *id est* following tonsillar infection, laryngeal diphtheria was very largely a preventible disease. It was necessary that parents should seek medical help promptly and that diagnosis should be made promptly in cases of suspected tonsillar diphtheria.

Principally as the result of the carrying out of these two conditions, secondary laryngeal diphtheria has decreased very greatly in Victoria. During the three years, 1910 to 1913, 4,705 diphtheria patients were admitted to Fairfield. Of these sixty-two had primary laryngeal diphtheria, and 797 secondary. For the three years, 1920 to 1923, the corresponding figures were 7,088, 303, and 493. That is, while the percentage incidence of primary laryngeal diphtheria, owing to the two great measles epidemics of 1920 and 1923, rose from 1.4 to 4.2, that of the secondary cases fell from 17 to 7 and the total percentage of laryngeal cases from 18.4 to 11.2. Not only this, but as a result of earlier diagnosis the percentage of patients requiring intubation or tracheotomy fell from 39.7 to 24.4.

These results obtained by the general practitioner should not be belittled. They represent work often of extreme difficulty, while by continuing his quiet work in the home on lines which I hope to make clear, he can do a great deal towards preventing the spread of the disease from one member of the household to another and do it by leisurely, easy and rule of thumb methods. Unless he be a medical officer of health, his province is not to find the starting point of a milk epidemic or a school epidemic, but to protect the other inmates of a house to which he has been called, and in which he finds a child suffering from diphtheria.

Now is it right in such a case for the family doctor to give the sick child antitoxin and a gargle or to send him to a hospital, to report the case to the health authority and forthwith to wash his hands of the business? He may go so far as to give the other children antitoxin as a prophylactic; the health inspector will come after a day or two and "disinfect" the house (not the inmates, be it noted) and may even "take swabs" from the throats of the other children. This will not do.

The sick child, it is true, may have been infected at school or in the play-ground or street, but he may have got it in the house. If so, it was not from the wall paper or the drains, but from some other person. All the other inmates are suspect; they should all be examined.

It might be said: "Will not the examination of cultures of swabs from the throats of these persons tell us all we need after only twenty hours delay?" Unfortunately it may not. The percentage of error is quite high. In many cases two and in some three such examinations are necessary to detect the presence of bacilli which actually are numerous and virulent.

There is a type of child in whom diphtheria becomes a habit, a type in whom, in addition to an unhealthy throat and nose, chronically inflamed tonsils and adenoids, there is an increased susceptibility to diphtheritic infection. Twenty years ago if such a child developed severe diphtheria, he was likely to die; nowadays he is likely to recover.

The healthy children of the present day who contract diphtheria, recover rapidly and with few exceptions the bacilli disappear from the throat and nose rapidly. But an unhealthy child of the type mentioned, if he recovers, becomes what is often incorrectly called a "carrier." The discharge from the throat and nose persists in continuous or intermittent fashion and as a rule the child suffers from recurring attacks of mild diphtheria. These children used to die; now they live and are the chief means of the distribution of the disease. To my mind if they could be rendered innocuous, diphtheria would disappear automatically. As it is, the bacillus is enabled to keep up and even to increase its virulence in the throats of these unhealthy persons whom we preserve and prepare for it. It should be the custom of the general practitioner then to be on the look out for such individuals in connexion with every case of diphtheria. Often they present obvious stigmata. To take a typical case. The family doctor is called to a house and finds a child A, ill with acute diphtheria. In the course of examining the other children he comes upon B, on whom his attention is immediately fixed. B. looks rather ill and pale, but is walking about. His throat shows no membrane, but he has a blood stained or brownish nasal discharge and scabs in the nostrils or excoriation of the upper lip, a coated tongue, perhaps hard enlarged cervical glands and impetiginous sores on the lips or chin. Now this child has diphtheria. If swabs are taken, they should be to confirm the diagnosis and after treatment has begun. He should be sent to hospital or isolated and treated elsewhere. He is a danger not only to his family, but to his school and the whole neighborhood.

Assuming that the other inmates are in good health, presenting none of these stigmata, I should advise no positive action in regard to them, not even the taking of a "swab" from the throat and nose of each. Whatever the microscope may reveal, our knowledge will not have been much enlarged. Healthy contacts who are not likely to be a danger to the community, may easily "carry" diphtheria bacilli for a few days. Thus if all the members of the family are swabbed indiscriminately and reliance is placed on the first finding, it is quite possible (I have known it to happen) for the dangerous B. to be let loose and the unfortunate and comparatively harmless breadwinner to be sent into isolation.

Still less is the indiscriminate injection of antitoxin as a prophylactic to be recommended. I have seen diphtheria develope on every possible day up to the twentieth, following such prophylactic injection. A thorough first inspection, followed by a more casual "look over" a few days later, is worth far more than these troublesome expedients.

What is to be done with those dangerous individuals, the sufferers from chronic or intermittent diphtheria and with the true "carriers," less often encountered and far less dangerous? The results achieved to date have been far from satisfactory and it is to be feared that the busy general practitioner will not be able to do very much. His part in which he has unequalled opportunities, consists in their detection and if he carries that out with the ability that he shows to-day in the diagnosis of faucial diphtheria, methods will be devised, we hope, which will prevent his labour from being lost.

The general practitioner has yet another duty to perform. It is, of course, necessary that any diphtheria patient treated in a private house shall be kept in reasonable isolation and as a matter of fact such isolation can be maintained quite efficiently in many cases. But when the patient is out of bed and feeling well again, it is the doctor's unpleasant duty to insist on further isolation until no signs of infectivity, physical or bacteriological, can be found. To determine the point, at least two successive swabs, taken from both the throat and nose, should fail to reveal any virulent diphtheria bacilli in culture. Now, "carriers" usually carry non-virulent bacilli; convalescents of less than one month's standing, very seldom. That is diphtheria bacilli obtained from a convalescent are almost certainly virulent. In the case of a particularly lively convalescent and still more in that of a breadwinner, the temptation to the family practitioner to be satisfied with one "negative swab" must be very great. One is led to the belief that he is the happier in the long run who sends all his diphtheria patients into hospital and sends them early.

In conclusion let no one think that diphtheria was once a deadly disease and is now a mild one. Many mild cases are now seen that once were unrecognized; many mild cases are now seen that are not diphtheria at all. But the disease remains the same, ready to strike if neglected for two or three days and it is the general practitioner who during the last few years has minimized its fatal effects. We look to him to go one step further and do his best to prevent its spread.

GENERAL MEASURES FOR THE CONTROL OF DIPHTHERIA, INCLUDING LEGAL CONTROL AND DISINFECTION.

By Thomas Walker Sinclair, M.D., B.S. (Melbourne), D.P.H. (London),
Chairman of the Commission of Public Health, Victoria.

Diphtheria is one of the diseases which have been the subject of control by legal means for a fairly long period. While it has been notifiable in Victoria since 1890, the reporting of cases did not become compulsory throughout the State for some years on account of the provisions of the Health Act. In New South Wales the disease was made notifiable in 1898, while in other States cases have had to be reported for periods of approximately similar duration.

It must, however, be unfortunately admitted that in spite of this control and notwithstanding the advances made in our clinical and bacteriological knowledge of the nature and methods of spread of the infecting micro-organism, the disease continues to persist steadily in our communities with periodic rises and falls in its incidence and mortality. In this connexion our experience is not singular for one finds records of similar conditions and fluctuations reported from other countries.

Indeed the opinions of some writers on the subject are that the elimination of the infection of diphtheria, as in the case of certain other diseases which affect the mucosæ of the throat and nose, is not within the bounds of possibility by means of isolation of persons and bacteriological tests. On these grounds they argue that better results in the incidence and mortality of the disease will probably be secured by measures for reducing the susceptibility of the population or at least certain portions of it by a system of artificial immunization (1).

While the importance of legal control by notification is sufficiently obvious and is regarded so by the general body of medical practitioners, its advantages are not always appreciated fully by the public. It may, therefore, be permitted to refer to its objects and benefits which have been briefly summarized by one authority as follows: "It has a distinct educational effect, renders possible certain steps for control, aids the discovery and removal of sources of infection and the removal of bad conditions, helps to provide more efficient treatment, gives local authorities direct information of the history and prevalence of disease and enables them to judge the effect of preventive measures." It seems scarcely necessary to add that in order to obtain its full value notification should be made as early and as accurate as possible and on this account full use of clinical and bacteriological methods of diagnosis is essential.

A study of the notification figures for the State of Victoria affords interesting material for consideration of the methods of control of diphtheria. Commencing with the year 1898 (Graph I.) when notification had become generally established, the incidence of the disease up to the year 1910 was comparatively low and varied within fairly narrow limits. The lowest incidence was in 1906, 7.91 per 10,000 and the highest in 1910, 18.83 per 10,000. A big rise occurred in 1911 to 38.76 per 10,000 and was maintained, except for slight falls in 1915, 1917 and 1919 till the year 1921, when the incidence reached its highest level of 61.52 per 10,000. The figures for 1922 show a gratifying reduction to 33.95 per 10,000 and so far this year shows a further reduction.

The notified incidence for the metropolis of Melbourne, as indicated in Graph I. shows that the course of the disease followed more or less closely that for the whole State. It is rather a striking fact, that for the period 1898 to 1909 the incidence of diphtheria in the State of New South Wales was comparatively low, but a definite increase occurred in the year 1910 and was more or less sustained till 1921, although the rates as shown in Graph II. are lower than those for Victoria. A gratifying reduction to 18.79 per 10,000 occurred in 1922 as was the case in this State.

A record of the deaths from diphtheria registered in the State of Victoria for the same period (Graph III.) shows that the disease was most fatal in 1898, viz.: 2.09 per 10,000 and that the mortality fell steadily except for the year 1904 to the lowest rate of 0.47 per 10,000 in 1906, which was also the year of lowest incidence. It then rose gradually till 1911, when there was a considerable increase and the second highest rate for the period, namely 1.89 per 10,000 was recorded in 1912. Since then comparatively high rates were except in the year 1917 maintained till 1922 when there was a large reduction to 0.87 per 10,000.

The mortality rate for the State of New South Wales during this period (Graph IV.) was 1.27 per 10,000 in 1898 and reached its lowest level 0.44 per 10,000 in the

Graph I.

Notification of Diphtheria per 10000; Victoria —; Melbourne ----

Graph II

Notification of Diphtheria per 10000 - New South Wales

Graph III

Death rate of Diphtheria per 10000; Victoria.

Graph IV.

Death rate of Diphtheria per 10000.- New South Wales

following year. Comparatively low rates followed until 1910, when a rise began and reached the highest rate for the period, namely 1.74 per 10,000 in 1913. Since then comparatively high rates have continued, except during 1919, until the year 1921, but were followed by a gratifying reduction to 0.97 per 10,000 in 1922. Although the rates generally for New South Wales are lower, they resemble more or less closely the mortality curve for Victoria.

The explanation for these variations in incidence and mortality offers no small difficulty. The greater attention paid to the milder types of the disease and the more general use of bacteriological methods doubtless furnish some reasons for the increase in recent years, but do not explain it entirely. It is difficult to estimate as well as trace the influence of some of the recent developements in our social habits, more especially the attendance at picture theatres which probably offers favourable conditions for the spread of infection of diseases that attack the mouth and respiratory passages. The higher mortality of recent years has afforded some grounds for the suggestion that the micro-organisms is increasing in virulence. An explanation offered by Scholes (2) for such a belief is that the children who get severe diphtheria, are those with unhealthy tonsils and post-nasal growths. Before the more general use of antitoxin these children succumbed. Now a large proportion of them recover, but owing to the unhealthy oro-nasal conditions become liable to repeated reinfection and he regards these children as the chief means for the distribution of infection. Whether the idea that an explanation for these variations may be furnished by some change in the infecting micro-organisms analogous to the "periodic mutation" of higher plants is probably a matter for conjecture, but Hamer (3) has pointed out what such might imply in the case of a disease, such as influenza, which assumes from time to time a pandemic phase. On the other hand, Dudley (4) suggests that during an epidemic of diphtheria a large portion of the community becomes immune to the disease without suffering from an attack; in other words there is a "coincident epidemic of immunity." This hypothesis, he considers, furnishes a more plausible explanation for variations in incidence than some unknown change either in the micro-organism itself or in the population.

The legal powers formerly provided for the isolation of cases of diphtheria, whether in hospital or in the home have, for a considerable time, been regarded as too limited for the effective control of the disease. On the other the part played in its spread by the infectious person who is either not clinically suffering from the disease or is suffering from it in some mild or a typical form, has in recent years assumed a very important position. Arising mainly from this more complete knowledge of the behaviour of the infection of diphtheria important extensions in the legal powers for control have become necessary. In the *Health Act* 1919 of Victoria a definition of the condition "carriers" has been included: "Any person having in his nose or throat or in his excretions or discharges germs of any infectious disease although presenting no signs or symptoms of the disease." The *Act* also provides under Part IV "Infectious Diseases" that every carrier of an infectious disease shall be "deemed to be suffering from the disease" and must be notified. Every medical practitioner is also required to notify a case, if becoming aware of the fact by *post mortem* examination or otherwise and the medical practitioner reporting a case must "inform the head of the household or the occupier of the premises and any person nursing or in immediate attendance on the patient of the infectious nature of the disease and the precautions to be taken to prevent its conveyance to others." These provisions should insure a more definite recognition of all types and degrees of infection and bring them under control, while they indicate to the medical attendant what has been stated editorially in *The Lancet* "that the prevention of disease is as much the rôle of the practitioner as the cure and care of patients."

It seems scarcely necessary to mention that the limitation of the spread of diphtheria like all other infectious diseases can be attempted only by full inquiry into all notified cases in order to trace the source and prevent the spread of infection. In *Infectious Disease Regulations* issued in 1922 in this State, such inquiry has been made mandatory for councils. In as much as the incidence and spread of disease is not limited by the boundaries of municipal districts, information must under these regulations be sent to the council of another district if the source of infection is believed to be in that district, while the council of the district where the patient works must be notified. These provisions constitute some machinery for control which is very necessary especially in contiguous urban areas, in the absence of one controlling authority for the incidence and spread of infection.

The part played by milk in the spread of diphtheria is well known and provision has been made giving a medical officer of health power "in the interests of public health or if he thinks expedient so to do" to forbid the same or removal of any dairy produce from a dairy or dairy farm where a case of disease has occurred and the owner or occupier of such premises must comply with such an order until "otherwise authorized by the medical officer of health." Particulars of the sources of supply and the names and addresses of the dairyman's customers can be "demanded by the medical officer of health." If the cause of infection is believed to be due to dairy produce from another district, the council of such district must be informed and is required to take the necessary action "to safeguard the public health."

These provisions meet fairly adequately the situation where disease has actually occurred on dairy premises or where there are reasonable grounds for suspecting a milk supply. Under *Regulations* for securing the cleanliness and freedom from contamination of articles of food "no person who is suffering from any contagious or infectious disease shall take any part in the preparation or manufacture or handling of any food for human consumption or use by any other person" and here we are met with the same difficulty in connexion with spread through milk, where the infectious person, as sometimes happens, is either not ill at all or only in trifling degree such as not to cause him to seek medical advice or is incubating the actual attack.

While the information furnished by swabbing of the

throat and nose is not as exact as one could wish, it is so far the only method available for determining if these passages harbor the bacillus of diphtheria or not. With a view of preventing the release of patients still harbouring infection and of minimizing the risk from the "carrier" condition *Regulations* passed in 1922 now require that "no such patient shall be released from detention until swabs taken at an interval of not less than forty-eight hours are declared negative by a pathologist." To meet the difficulty sometimes experienced of the continued persistence of infection in the oro-nasal passages, *Regulations* provide that "in the event of a carrier remaining positive after the expiration of one month from isolation, the medical officer of health may release him, subject to such conditions as may be imposed and in the case of failure or neglect to comply with these the medical officer of health shall take such action as is necessary to again isolate such carrier." This provision appears to afford opportunity for obtaining the correction, by suitable treatment, of the unhealthy conditions (enlarged tonsils and post-nasal growths) which are generally recognized to favour the persistence of diphtheritic infection, while limitation can be applied against the employment of persons in the preparation of foods notably milk for human consumption. Moreover, the release of a patient can be permitted where the infection is found to be a non-virulent type.

Infection by contact is no doubt the most important means of spread in diphtheria and the swabbing of contacts, by which is meant "every inmate of a house wherein a case of disease has occurred" is made a compulsory duty on the part of councils, unless this work has been carried out by the medical attendant. Special control "by isolation, over "contacts attending school or under school age" is provided "until a negative swab is obtained." Other contacts are "subject to surveillance by the medical officer of health."

Although the prophylactic use of antitoxic serum has been recognized for many years, only recently have its protective limitations been defined. On the other hand the longer duration of the protective value of inoculation with toxin-antitoxin, as well as the important evidence in regard to susceptibility as determined by the Schick test have been amply demonstrated. Hitherto the employment of these measures has been, more or less, an optional matter, but the following general regulation requiring that a "council on the recommendation of its medical officer of health shall provide for the supply of drugs and other substances for the prevention and cure of infectious diseases and for the accommodation of patients and such medical nursing and other aid to patients as may be necessary" does, I feel, afford scope for the compulsory adoption and employment of these important measures against diphtheria.

Disinfection.

The ideal method of disinfection is "to destroy the infective material as it leaves the body." The personal element in the infection of diphtheria, *id est* directly and immediately from one person to another by means of oro-nasal discharges, has without question come to be regarded as the principal avenue of spread of the disease. It would, therefore, appear that prevention of such spread would be a fairly simple matter. The difficulties in securing such a result are due to the mild and atypical forms of the disease which often are unsuspected or do not come under treatment and to the want of what Rosenau describes as "habits of biological cleanliness" in the community. Although it has been reported (5) that virulent diphtheria bacilli have been isolated after fourteen days from pen-holders sucked by boys harbouring these organisms in their mouths, the possibility of contracting infection from premises occupied by a case of the disease is rather remote and for this reason the so-called "terminal" disinfection after cases of the disease is probably of little value so far as prevention is concerned. The destroying of infective material as it leaves the body, or what has been termed by one writer (6) "current disinfection," implying "the daily and if need be hourly disinfection of the discharges and secretions of the patient, the cleansing of utensils used in feeding and the placing in some disinfecting solution of the soiled articles such as pillows, sheets, handkerchiefs, etc., with absolute cleanliness in the house" constitutes the most rational and effective preventive measure in this connexion. While "terminal" disinfection may not now be regarded scientifically as an effective preventive measure, spraying of rooms and effects does especially in houses of the poorer classes secure the important subsequent advantage of general cleansing and aeration and for these reasons one feels inclined to its retention.

General Measures.

Omitting reference to methods of immunization, it has to be admitted that the results of general sanitary improvements in cities have been much less marked in regard to the incidence of diphtheria than in certain other infections. However, the effect of improvements in housing by securing adequate ventilation and sanitary conditions, coupled with the abolition of congested areas and the provision of more open spaces in towns must at least have the result of increasing bodily resistance and indirectly tend to limitation of the spread of infection.

The principal general measures concerned with the control of diphtheria relate to education, milk supply and school attendance.

While the community generally is becoming more alive to the knowledge of the variation in virulence of attacks of diphtheria, there is still much ignorance and indifference especially amongst the poorer classes as to the risks from mild attacks of sore throat and chronic inflamatory conditions affecting the nose. The possibility of such being due to the diphtheria bacillus is well known and this fact should be grasped by medical practitioners, in addition to being impressed strongly on the minds of persons generally. The methods of spread of the disease must be persistently stressed in order that "habits of biological cleanliness" may become general and the "commerce or exchange in saliva" referred to by Chapin may be minimized or abolished. In this work the employment of trained nurse-inspectors for visitation of homes and schools, coupled with the circulation of leaflets embodying the precautions against the spread of the disease, constitutes an important factor.

The predisposition to attack which is incurred by children with unhealthy oral and naso-pharyngeal conditions

must also be emphasized, and their removal by suitable treatment advocated, wherever such is indicated. When these matters receive the consideration which they deserve, not only should there be a lessening of the incidence in homes and in schools, but the risk of spread by infected milk should be minimized.

While the part played by milk in the spread of infection is recognized as an important one, I feel that it constitutes a smaller factor than what is generally supposed. In United States of America the disease prevails extensively, in spite of the fact that Pasteurization of milk is so largely employed on probably the best lines that we know. In Chicago (7) where 98% of the milk supply is Pasteurized, the incidence of diphtheria in 1921 was 33.49 per 10,000 and the death rate 2.43 per 10,000, figures which correspond approximately with our own. While not desiring to minimize the value of Pasteurization in contributing to the prevention of infectious disease, I would emphasize the greater attention that must be paid to other avenues of spread, which are doubtless more difficult to control. The medical examination of all persons engaged in milk production and distribution is scarcely a practical measure, even if much good would eventuate from it unless repeated at more or less frequent intervals. What is possibly a more feasible consideration is that those engaged in this business should be made aware of the danger to others of certain mild forms of illness already referred to and the necessity for prompt determination of their nature by medical and bacteriological examination. Under the conditions, however, which generally prevail at present, I feel that Pasteurization of milk by the trade or domestically in the home is a method which should be recommended both for its advantage against diphtheria and other infections.

Our views in relation to the part played by schools and school attendance in the spread of infection have, in my opinion, assumed a more rational form. Interference with school attendance of children is by no means a trifling matter and, unless there is good reason for such, they should be avoided. Our guide to action in this connexion must largely depend on a close watch being kept on the notified incidence of the disease in relation to these establishments. School closure as a means of control now figures much less in this connexion on account of more correct and defined principles being followed. The so-called "mass-swabbing" (1) of large groups of school children scarcely meets the position which has to be faced, and its results can hardly be considered satisfactory or worth the labour involved. What to my mind is likely to prove of greater value as a measure of control is medical examination of individual classes or groups of children, combined with the taking of swabbings where considered desirable.

Such a procedure can be repeated as often as is found necessary and in this connexion I would emphasize the importance of paying attention to the condition of the nose and the necessity for taking swabbings from the nasal passage as well as the throat.

A matter of importance affecting schools is the education of teachers to a knowledge of those mild conditions where the causal factor may be diphtheria. An intelligent appreciation of such by teachers and school nurses would prove a further valuable advantage in reducing the risks of spread through school attendance, while at the same time minimizing interference with school work generally.

Isolation of cases of the disease, as a means of control, scarcely requires to be emphasized at this date. Though the introduction of special isolation hospitals has not effected the reduction in incidence which was at first hoped for, they have shown the necessity for their existence in other ways which quite warrant their establishment. In the majority of homes and other residential premises where cases of diphtheria occur, the opportunity for securing effective isolation is not within the bounds of possibility, to say nothing of efficient treatment and removal to isolation hospital becomes a matter of absolute necessity.

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THE PLACE OF INDUSTRIAL HYGIENE IN THE GENERAL SCHEME OF DISEASE PREVENTION.

By A. J. Lanza, M.D.,
Commonwealth Department of Health.

The art of medicine as applied in industry by the industrial physician does not differ from the same art as practised by the qualified practitioner under any other set of circumstances. Yet it would be a mistake to conclude that the industrial physician, the exponent of the art of industrial hygiene, is a transplanted general practitioner any more so than is the school medical officer. This does not imply special qualifications on the part of the industrial physician, but rather the existence of opportunities which the growth of industrial medicine has created and which are tending more and more to establish this as a distinct branch of the medical sciences.

The industrial physician may be defined as one who gives all or part of his professional services to industry, in which latter term we include the factory and mine, the large mercantile establishment and the various branches of the public service. He deals with the most important section of the community, the producers, during their years of greatest activity.

The industrial physician is more of a public health official than is the general practitioner; like the school medical officer he has a greater opportunity of concerning himself with prevention. He is in intimate touch with his *clientèle* at all times and is in a position to assume the initiative rather than to remain passive until his ser-

vices are called upon. He is an active force in preventive medicine in a two-fold manner. He has the opportunity of treating both medical and surgical cases of a minor type that otherwise do not often reach medical assistance, and he thus helps many patients to avoid the more serious disability that would occur at a later stage were such early treatment not forthcoming; at the same time he is in a position to appreciate and constantly to influence the physical and mental well being of the entire personnel under his charge. He has a knowledge of the industry, the conditions of work, the nature of the various processes and can bring to bear a watchfulness and a supervision that will offset influences unfavourable to health. The efficiency of the industrial medical department is judged not by the number of persons who pass through it seeking relief, but by the amount of time lost through illness among the employees. In his ability to reduce this amount of illness below the general or accepted average lies the test of the industrial physician.

In this conception of the industrial physician as a specialist in preventive medicine, whose duties go far afield of remedial treatment, is revealed the potential service of industrial hygiene to the community.

Modern medicine has enormously increased our comprehension of the infectious diseases. Some of these have been robbed of nearly all their terrors and no longer are to be found among the leading causes of mortality. That infectious diseases are not less prevalent is due not so much to lack of knowledge as to failure to apply our knowledge. This is often a question of practicality, but at least the physician and the public health official have a fairly well defined target at which to shoot. In marked contrast we have those types of disease which represent the effects of the wear and tear of daily life, the failure of the individual to adjust himself to his environment. The insurance companies and the vital statisticians inform us that the so-called degenerative diseases are on the increase and their evil effects are most pronounced during the years which should constitute the prime of life. Nor in this connexion should we overlook cancer the ætiology of which is still a mystery. We have then groups of diseases which are becoming of more and more significance, as shown by the mortality tables, about which our knowledge is limited and our practice, in so far as prevention is concerned, nil. In this domain largely lies the future of industrial hygiene

As ordinarily understood industrial hygiene comprises, firstly, the adaptation of the worker to his job. This is accomplished by the physical examination, conducted not for the purpose of excluding the unfit, but as a guarantee that no person be placed in a position where he may be a source of danger to himself or to his associates and that each individual as far as possible may be employed to his best advantage. Secondly, it comprises the regulation of working conditions, supervision of ventilation, illumination and other physical factors and the safeguarding of processes dangerous either mechanically or chemically. In the third place it makes provision for the early recognition and prompt treatment, either medical or surgical, of illness due to or arising in the course of occupation. In the purely industrial aspect as differentiated from the rôle of governmental supervising agencies these three items comprise the routine functions of the industrial physician and the industrial medical department. The tremendous economic importance of these functions have been amply demonstrated, but cannot be discussed here.

But over and beyond all this lies that fertile field of investigation wherein are included the groups of diseases to which I have just alluded. It is not to be implied that there can be saddled upon industry the responsibility for these diseases, although, apart from the specific occupational disorders, the relationship between industry and disease is a closed book and is the subject of numerous misconceptions. But the assemblage of large groups of persons of both sexes and varying ages in industrial establishments, while it has resulted in bringing about so many of the complex problems of modern times, has at the same time put into our hands the remedy, the very weapon with which to combat disease and death, and ours is the fault if we fail to use it. For in this congregation of many persons, in one place and for a definite time, we have an opportunity of studying the tide of disease, the to and fro fluctuations of abnormality, to an extent that can be otherwise approached only in schools and military forces.

The industrial physician offers to preventive medicine the vital statistics of the industrial worker, vital statistics in which more stress will be laid upon the chronicling of illness than upon the recording of mortality. There will thus gradually become apparent the physical status of the community and the types of disorders to be found at different age groups and in different occupations. Deviations from the normal will be more readily recognized and the gradual undermining of vitality which terminates in one or other of the constitutional diseases, will be more sharply defined for attack. The hospital, the general practitioner, the research worker, the health officer all fit into the scheme at one point or another, but the keystone of the structure must be the physician who can bring a sound medical training to bear upon an intimate knowledge of and association with industry and the industrial worker.

This is not a fanciful picture. While many persons are employed in small establishments, yet there are a sufficient number in the larger ones to supply us with a reliable cross section of the community, for besides the private companies there are the great groups in the public service, the railways and the post and telegraph. There are at present in Melbourne and Sydney no less than seventeen medical practitioners who devote all or part of their time to industry, and a number of these are developing their medical departments in conformity with the ideals I have been discussing. Most of these medical departments are new and with them it is merely a question of time, organization and will; the opportunity is already at hand.

It may be objected that lodge practice, as ordinarily understood, is in truth the means of establishing contact between the physician and industry and as such is sufficient for all practical purposes, but it must be apparent that such a form of practice can never fulfil the possibilities for disease prevention inherent in industrial medicine. There is needed the association, not with individuals, but with groups where individuals are considered in relation to each other and as component parts of the whole, to give us such a knowledge of environmental conditions and

other factors as will enable us to do intelligent preventive work. In all this the general practice of medicine is not affected any more than it is by other forms of specialization.

It should be clearly understood by the entire community, and this is a responsibility of the medical profession itself, that these questions of national health and vitality and their association with industry revert to the basic facts of anatomy, physiology and pathology. To cope with them successfully we must depend upon the well trained physician; the efforts of the layman, the welfare worker, the untrained enthusiast, if unassisted by the medical scientist, can result only in confusion.

To summarize, industrial hygiene, apart from its routine functions which are both preventive and remedial, offers a substantial increase in our knowledge of the physical status of the community and of the incidence and ætiology of disease and thus provides an intelligent basis for further disease prevention.

MORBIDITY FIGURES OF VARIOUS PUBLIC SERVICE OCCUPATIONS.

By Frank R. Kerr, D.S.O., M.B., B.S., D.P.H.,
Commonwealth Department of Health.

During the last two years the Division of Industrial Hygiene, Commonwealth Department of Health, with the valuable assistance of Mr. Wickens, Commonwealth Statistician, has been engaged in the collection and study of the morbidity statistics of various government departments, in order to secure knowledge of the risks to health of these various occupations and to have sufficient data for their comparison on a scientific basis with other similar callings.

Victorian State School Teachers.

An inquiry was made into the health of the Victorian State School teachers during the years 1914, 1920, 1921 and 1922. The number of teachers studied varied between 2,126 males and 3,223 females in 1914 and 2,276 males and 4,202 females in 1922, making about 6,000 in all each year.

From the various observations the following facts were deduced:

(i.) The average number of working days a year lost through sickness by each teacher was 7.62, by each male teacher 5.00, by each female teacher 9.09.

(ii.) The percentage of male teachers suffering from illness lasting over two days varied from 18.68 in 1914 to 23.33 in 1921, of female teachers from 32.11 in 1914 to 36.75 in 1921.

(iii.) The age-periods during which male teachers exhibited most sickness were under twenty-one and from fifty-six onwards; female teachers were most often ill between the years of forty-one and fifty-five, enjoying the greatest amount of health before the age of twenty-one.

(iv.) The principal *disease groups* causing sickness were the epidemic, endemic and infectious diseases, the diseases of the nervous system and organs of sense and the diseases of the digestive system.

(v.) The chief *diseases* affecting teachers were the diseases of the upper respiratory passages (including influenza) and neurasthenia; influenza and allied diseases caused among males in 1914 16.73% of sick leave, in 1920-1921-1922 13.45%, among females 20.53% and 18.29%; neurasthenia caused among males in 1914 10.67% of sick leave, in later years 15.56%, among females in 1914 15.50%, in 1920-1921-1922 15.67%.

(vi.) Omitting influenza and tuberculosis, the ordinary infectious diseases caused in males 5.91% and in females 7.98% of all sick leave.

(vii.) Laryngitis was 4.58 times as common in a given number of females as in the same number of males.

(viii.) Anæmia caused 3.41% of sick leave in 1914 among females and as much as 7.31% in 1921; and 21 to 25 and 26 to 30 were the principal ages affected.

(ix.) Of all women 79.90% do not suffer at all or only have a slight loss of efficiency through menstruation.

For purposes of comparison the only literature discovered on the subject of the illness of teachers was the description of an inquiry made by J. W. Hart, (1) into "The Sickness Data of Public Elementary School Teachers in London 1904-1919." His conclusions were as follow:

1. The mean illness of men teachers was 4.6 days a year, of single women 8.2.
2. The healthiest period for men was from 30 to 40, and the highest figures were given by those over 60. Single women showed greatest sickness from 46-55, and again from 61-65. The youngest years were the healthiest. It should be noted that age-group under 21 was not included in the investigation, and with this omission the same age-groups were employed as in the Victorian inquiry.
3. That pulmonary, bronchial, and throat complaints (including influenza) were the chief causes of sickness and were responsible for 43% of total illness; that neurasthenia and nervous breakdown were next with 16.5%, gastric complaints 8%, infectious diseases 3.8%, and anæmia 3.7%.

A comparison will show that the results of both inquiries are very similar. An improvement was made in Australia by using the International Classification of Diseases. The number of days lost in Victoria are slightly in excess of the London experience, but the age-grouping conclusions are almost identical. The high figure (43%) for the principal cause of sickness is undoubtedly due to the fact that the group included all pulmonary diseases. In the Victorian results only the diseases of the upper respiratory passages are referred to. The figures for neurasthenia are practically the same, but the infectious diseases and anæmia are shown to be more prevalent among our own teachers.

It has been shown that sickness among the Victorian school teachers is slightly in excess of that experienced by the British teachers. This is to be expected, considering the inaccessibility of many of the country teachers, compared to the ease with which the London teachers can be medically supervised.

An attempt was made to estimate as far as possible any effect which might be produced by the function of menstruation upon the efficiency of female teachers. It was found that 20.10% of female teachers were absent during the four years studied on account of menstruation. This means that 79.90% were not compelled to remain off duty, or if affected at all, were absent not more than one hour during any particular session.

This result bears out the findings of Dr. Margaret Sturgis, (2) who in 1922 studied 2,077 working women in Pennsylvania. Questioning each one as to discomfort, pain and loss of time, she found that 65% were able to continue their work during the menstrual period with little if any discomfort, 30.6% suffered slight disablement, needing perhaps a short rest and only 4.4% were so affected as to be completely unfit for work. The 79.90% in the Victorian inquiry covers the whole of the 65% whose work was uninterrupted, as well as a few of the 30.6% who needed perhaps an hour's rest.

These figures are an indication then that the working capacity of most women is little, if at all, influenced by menstruation. If it is true that for the great majority of women the menstrual function is no handicap, it should aid much in raising their status in industry.

In considering the average number of working days a year lost through sickness by each teacher (namely 7.62) we must remember that the teacher is not exposed to the diverse risks of many other industrial workers. His work is purely mental and on the whole his life is a safe one. The actual time of exposure to the effects of occupation is also less than in the case of the great majority of workers. The Victorian teacher works for about two hundred and nineteen days in the year, has short hours and enjoys long vacations in which to recuperate. Many other workers on the contrary are subject to the specific risks of their trade for about two hundred and eighty days a year, are employed for long hours and are blessed with only a short period for rest. Everything is in favour of the teacher's occupation being comparatively a healthy one.

Do the figures justify this conclusion? Let us look first at the results of other inquiries recently made.

Taxation and Postal Departments.

Another investigation made was the study of the morbidity history of the Central and Victorian Taxation branches of the Treasury and of the Victorian Postal Department. The 4,826 officers concerned in these three departments had 51,167 days' sick leave in 1921, averaging 10.6 days *per annum* per officer. Females were considerably in excess of males in amount of illness. Respiratory diseases were accountable for as many as 8,659 days of sickness or 16.9% of the total, but neurasthenia headed the list of individual diseases, being responsible for 5,306 days or 10%.

The figure 10.6, the average number of days' sickness per employee, is high for clerical work. The working year is about two hundred and seventy days.

Victorian Railways.

A comprehensive survey was also made of the sickness records during 1921 of the Victorian Railways employing 25,821 men. The total number of days' sick leave granted to these employees was 159,076, or 6.16 days per worker and the average duration of sick leave was 17.26 days.

The epidemic, endemic, and infectious diseases accounted for 20.666 days or 13% of the total, nervous diseases 17,186 days or 11% and respiratory affections 16,928 days or 10%. Influenza was responsible for 9% of the total and neurasthenia for 8%.

In an occupation such as this, injuries are a big factor and are expected to produce a great amount of disability. Accidents caused 45,096 days of absence, 28% of the total and of these nearly one-half were due to injuries to the lower limbs. The total loss of time due to illness and accidents amounted to 568 work years, while accidents alone were accountable for a period equivalent to 158 work years.

Another department studied was found to have in one year 97,427 days of sickness experienced by its 11,921 officers, amounting to about eight days each.

At the end of 1920 there were 493,978 benefit members of the various friendly societies and during that year the total number of weeks' sick pay granted was 545,073, or about 6.6 days per member.

From all this information it can be safely estimated that the average loss of time annually through sickness by each industrial worker in Australia is from six to eight days.

The American experience is similar. An investigation was carried out by Dean K. Brundage (3) of the United States Public Health Service, who showed that in 1920 1,282 office-workers lost through sickness 8.15 days per person. The majority of the employees were women, the average age was 23.7 years and the work was relatively free from health hazards. Thus the results are comparable with those received for the Taxation and Postal Officials and the School Teachers, except that the last-named worked for a much shorter year.

The Committee on industrial waste of the Federated American Engineering Societies (4) reported that in 1921 "the 42,000,000 men and women gainfully employed (in the United States of America) probably lose on an average more than eight days each annually from illness disabilities."

It was ascertained that the female employees of the Postmaster General's Department in Melbourne lost in 1921 through sickness 10.6 days each in a year of about two hundred and eighty days. The 9.09 days per female teacher in Victoria are equivalent to 11.62 days in the ordinary working year $\left(\frac{9.09 \times 280}{219}\right)$. Thus each female teacher was absent on an average 1.02 days a year more than the female postal department worker.

We must conclude then:

(1) That the Victorian State School teacher as a whole shows a slightly higher sickness experience than we would expect (7.62 days in a year of 219 days).

That the male teachers (5.00) are below the average, though slightly in excess of the London male teacher, while the females (9.09) compared with American office workers, Victorian female postal employees and English female teachers show a slightly excessive sickness rate.

(2) That the taxation and postal officers (10.6) are greatly in excess as regards sickness, in comparison with other similar occupations.

(3) That the figures of the Victorian Railways (6.16 days per man) are towards the low side, considering the hazardous calling of many of the employees.

Dealing with the minimum we may say that a loss of six days out of a working year is equivalent to the incapacity of 2% of the total industrial population of Aus-

tralia. That is to say, the labour of 30,000 people is lost to the Commonwealth every year on account of sickness.

Similarly, the figures of the friendly societies show that the 493,978 members lose 6.6 days a year and this is equivalent to the loss of the labour of about 10,000 of their adherents annually through illness.

If we can by careful thought reduce the amount of time lost through illness annually by each industrial worker in Australia by one day, it would mean saving for the nation what is equal to the labour of 5,357 workers during one year.

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GLIMPSES INTO A TRAM MAN'S LIFE WITH SPECIAL REGARD TO OCCUPATIONAL DISEASES.

By Carlton A. Ellis, M.R.C.S., L.R.C.P. (London). F.R.C.S. (Edinburgh),
Surgeon-Commander, Royal Australian Navy.

Although I esteem it a great honour to be asked to read this paper; at the same time it was with much diffidence and in all innocence that I consented to do so, not realizing the difficulty of my task.

The statistics compiled are the result of deductions made from 3,330 examinations of men, when acting as Medical Officer to the Melbourne and Metropolitan Tramways Board. These observations are rendered more valuable, however, as no attending is done at the head office, but simply the results of the general practitioner, (who is in most cases the lodge doctor of the employee) are tabulated and commented on, he again calling in a specialist if in doubt. This makes the observations doubly valuable.

These records are incomplete for two reasons. Firstly, except in doubtful cases I never see a man who is ill until he has been on the sick list for sixty days; secondly, as it was essential for the safety of the general public it was considered highly desirable that the preliminary examinations should be completed as soon as possible for such things as sight, hearing, hernia and the like. Blood pressure readings which are high in so many old employees, were taken only in rare instances. The vital things (until the examination of the whole 5,000 employees is finished) are vision, colour vision and hearing for traffic work.

My instructions from the Chairman on appointment were: "For the old hands, be as lenient as you can, for the new men, be as strict as you like." Acting on this, perhaps many of you who live in or visit Melbourne will have noticed the increased number of men engaged in traffic work—gripmen, motormen and signallers—who had to take to wearing glasses. In every case, when possible, these were prescribed by a skilled oculist.

Men suffering from cataract, very defective vision, marked deafness and the like were, owing to the kindness of the Board, transferred to other jobs such as shed or other work at which they were not likely to injure either themselves or any of the travelling public.

I propose, if possible, to examine all traffic men every three years and all other employees every six years.

The Tramways Board is faced with the problem of providing full travelling facilities for the public and drawing up rosters of work which will give the maximum of work with the minimum of irregularity. The Board realizes all the drawbacks which, besides being unpleasant, cannot be eliminated. All that can be done, then, is to recognize their existence and grant compensation.

A very complete understanding, for instance, exists between the Tramway Employees' Association and the Tramways Board and these disabilities are recognized on both sides. During the last fifteen years the successive agreements which govern the working conditions of tramway occupation, have been amended and amplified until it is now difficult to indicate a disadvantage which does not carry its reciprocal compensation.

The incidence of traffic brings the "peak" as we call it or heaviest loading for two hours in the morning and two hours in the evening and to the most casual observer it is apparent that at these times with every available car in commission the resources of the Board are taxed to their fullest extent.

The work of traffic men is, generally speaking, divided into night and day shifts. A man on night shift suffers less irregularity in his meal hours than when on day duty, as he commences work on most tables somewhere between 2 p.m. and 4 p.m. and can take his two first meals at home at ordinary times. Tea relief will almost certainly be between 5.45 p.m. and 6.45 p.m. These shifts are worked on alternate weeks and are based on the principle of forty-eight hours per week spread over six working days with one day off in seven. Thus he works on an average every second Sunday and nearly every holiday; such work carries an extra 50% remuneration. In addition he obtains a fortnight's leave of absence on full pay each year and, of course, receives one day off each week. Overtime is paid for at 25% and 50% extra rates and should his eight hours per day be spread over the morning and evening peaks, say from 8 a.m. till 7 p.m., time off being allowed during the slack loading hours, he obtains a further quarter or half rate of wages. Although his hours are irregular and to an outsider very complicated and confusing, a scientific roster is prepared by which he is informed his exact hours of duty every day for twelve months ahead, and every man "rotates round the roster" so that he shares the good and bad shifts equally.

The Tramways Board has facilitated the formation of a benefit society among its employees, which carries the usual friendly society's sick pay, medical attendance, medicines and funeral allowances. The Board pays one-half of each member's weekly contribution. When the

employee falls sick, he receives £1 per week sick pay. If he be injured on duty, he will also obtain from the Board's Workers' Compensation Insurance Policy an additional £2 per week. Should he be so unfortunate as to lose his life as the result of an accident whilst on duty, his dependants will obtain up to £500 compensation. Injuries of a permanent nature carry a definite scale of compensation. Quite apart from these statutory accident compensations, the Board grants a retiring gratuity to every employee of ten years' service who has reached the age of sixty years or who, having attained the age of fifty-five, dies whilst in the Board's service.

At the wish of the Board I inspected all depôts and car houses with a view to suggesting sanitary improvements. I am glad to say that without exception in every case possible these reforms were adopted at once, except in cases where the old buildings were likely soon to be scrapped. I had to point out in one depôt which had much outgrown its size, the conveniences supplied were so limited that an epidemic of increased peristalsis would have been disastrous. I was told while going round that a notice which had been put up by one line manager but had been removed, was as follows: "Cleanliness counts for promotion. Employees must not commit themselves to be a nuisance."

First aid cabinets have been installed into all depôts (including its head office) and I have suggested that if a man qualifies in first aid work, one or two men in each depôt should be paid three pence or more a day to be held responsible for directing affairs until the doctor arrives in case of accident.

The vital statistics which you have before you, will, I hope, ere I finish prove to you that the tramway occupation is one of the most healthy pursued in this city at the present time. I do not want you to think that tramway men never grow old or die, but I want you to take an optimistic view. I have heard it said many a time that varicose veins, nerve diseases and flat feet are caused by work on the trams. After careful analysis I have come to the conclusion that the above diseases are common, but that in most cases these troubles are aggravated by and not attributable to tram work. There is a tendency to the particular diseases from which the men suffer before they take up traffic work. For instance, 75% to 80% of the new recruits are more or less flat-footed before entry. If we rejected this number we should have no one to work the trams. On the other hand, I have seen an old man who has been forty years on horse-bus and tram who, if provided with silk stockings, would be a credit to any ballet!

For new recruits the standard I have set up has been deliberately high. Owing to the large number of applicants, we can afford to pick and choose only the perfectly fit.

You will notice that 2,002 tramway employees of all sections were examined and only 606 regarded as perfectly physically fit. The results of the general analysis are set out in Table I.

With regard to sight my point is that if we start with a standard for traffic of less than 6/9 in a young man of twenty-two, where are we going to be in twenty years time? I maintain again that the predominant features in the traffic men are eyesight, colour vision and hearing. With regard to varicocele I have noticed in my Navy experience that if a man with varicocele did not want to do any certain job, whether it was marching or standing, his "varicocele went back on him."

In addition 1,005 candidates for admission into the Tramway Service have been examined, with the result that two hundred and eighteen were rejected.

TABLE I.

Complaint	Number	Average Age	Average service in years
Defective vision [1]	1018	49 $\frac{9}{12}$	16 $\frac{11}{12}$
Varicose veins	138	46	14
Heart disease	65	47	17 $\frac{6}{12}$
Hernia	43	46 $\frac{6}{12}$	14
Varicocele	38	43 $\frac{9}{12}$	16 $\frac{6}{12}$
Old injuries	13	30	10 $\frac{4}{12}$
Gastro—intestinal	22	33	4 $\frac{1}{2}$
Deformities	20	40 $\frac{6}{12}$	13
Miscellaneous	39		

[1] Standard vision is 6/9 in each eye.

TABLE II.
Causes of Rejection.

Complaint	Number	Average Age
Defective vision	65	31 $\frac{8}{12}$
Deformities (mostly feet)	41	30
Heart	22	28 $\frac{9}{12}$
Varicose veins	22	33 $\frac{5}{12}$
Teeth and gums (pyorrhoea)	18	28
Varicocele	9	27
Hearing	9	27 $\frac{5}{12}$
Hernia	7	28
Physique	9	26 $\frac{4}{12}$
Miscellaneous		

It is obvious that those who control the tramway service can, because of the attractive nature of the occupation, staff it with a select group of men. They can ask for complete physical fitness and are right in doing so. It is economical from every point of view. It would be wrong, however, to deduce from the figures furnished that a large proportion of Australians are unfit.

I have a chart which I should like you to study for a moment. It shows the curve of sickness on both cable and electric systems. You will notice that the cable service has definite rises which all take place when the weather is bad; while the electric system which is more protected, is consistent.

Cable tramway gripmen have more arduous work than motormen on the electric system. The brakes of the latter are more easily worked and but little strength is required by the motorman in manipulating the power in comparison with the heavier work of the gripmen in gripping the cable after each stoppage. They also work in more crowded thoroughfares than the motormen, demanding greater attention and are in a situation more exposed to the weather and the importunities of the public.

After taking everything into consideration, I think I have proved my point that tramway occupation is from a medical point of view as healthy a one as any other, if not more so.

OBSERVATIONS ON INDUSTRIAL MEDICINE IN AUSTRALIA AND OTHER COUNTRIES.

By D. G. Robertson, M.D., D.P.H.,
Director of the Division of Industrial Hygiene, Commonwealth Department of Health.

(The article as published is an abstract of the paper read at Congress.)

Industrial medicine is an essential part of the public health programme; its sphere is confined not merely to the factory and workshop, but embraces all places where work is carried on. Its aim is to help both employer and employees to make use of the resources of science in reducing the suffering and loss due to physical disabilities, disease, and premature death.

The safeguarding of dangerous and unhealthy trades is necessarily an important function of government. The legislative and administrative control in Great Britain of these trades sets a good example, the *Factories and Workshops Acts* giving power for regulations to be made governing any occupation dangerous to life or limb. One feature of these regulations is compulsory periodical medical examination of the workers engaged. The notification of certain specified occupational diseases is compulsory in Great Britain and some other countries. Australia may follow with advantage these examples.

Governmental Medical Supervision in Industry.

Great Britain and Belgium have appointed medical inspectors of factories to investigate reported cases of occupational diseases, conduct research work, and supervise the certifying factory surgeons whose duties include the granting or refusing certificates of fitness to young persons under sixteen years of age within seven days of employment, the reporting on cases of specified industrial diseases or poisons, the periodic examination of work people in certain dangerous trades, and the examination of those suffering from certain industrial diseases under the *Workmen's Compensation Act*. In Great Britain the Industrial Fatigue Research Board is undertaking researches to promote better knowledge of the relations of hours of labour and of other conditions of employment, including methods of work, to functions of the human body, having regard both to the preservation of health among the workers and to industrial efficiency. A Commission appointed by the Washington Conference, 1919, of the International Labour Organization in its report expressed the hope: "That medical inspection to safeguard the health of the workers will be instituted in all countries, that disability due to occupational diseases will be compensated, and that all such cases of occupational disease will be notified by physicians." Australia to-day has no medical men attached to the labour departments.

Welfare of Workers.

In Great Britain the Secretary of State may, by order, require the occupier of any factory or workshop to make special provision for securing the welfare of the workers. Many of the orders enforce the provision of first aid boxes and ambulance rooms. A "miners' welfare fund" has been created in Great Britain under the provisions of the *Mining Industry Act 1920* and is derived from a levy of one penny per ton of the output of every coal mine. The definition as to the objects of the fund is as follows: "Purposes connected with the social well-being, recreation and conditions of living of workers in or about coal mines and with mining education and research." A similar levy made on Australian coal would provide the means for research into many interesting problems.

Social Insurance.

The National Health Insurance Acts, 1911-1921, Great Britain, ushered in with such intense oppositions from the British Medical Association, have not proved so detrimental to the profession as at one time it was feared, judging by a quotation, eulogizing the Act, made by Dr. Douglas, Chairman of the Insurance Acts Sub-Committee (Scotland), at a conference called by this Sub-Committee and held in Edinburgh in July, 1923. Evidence available proves that the number of days lost by the worker is eight to ten times greater from sickness than from accidents, a fact which makes the consideration of the introduction of similar insurance in Australia most desirable. Regarding *Workmen's Compensation Acts* it is not universal in Australian States for industrial diseases to be included. One difficulty in the way are those industrial diseases taking years for the effects of occupation to manifest themselves. In Great Britain the Refractories Industries (silicosis) Scheme gets over this difficulty by having payments made out of a general compensation fund, maintained by subscriptions levied on all employers engaged in the industries. The direct aim of *Compensation Acts* is twofold, to restore the injured to industry as completely and quickly as possible and to provide for the support of the families during the period of disability. Australian States might, with advantage, consider the amendment of their laws to include provision for payment by the insurer of medical and hospital fees incurred by the injured, as is done in several of the American States. In America and on the continent particular attention is being paid to reconstructive surgery and vocational rehabilitation of the industrially crippled. The establishment of special orthopædic clinics in Australia might well be considered.

Medical Service in Industry.

There is a growing appreciation among alert and forward looking employers of the economic worth in their enterprises of initiative or cordial cooperation in various forms of organized health and recreation activities. America's leading industrialists are setting a brilliant example in this respect. Their medical departments are the last word in efficiency. The duties of an industrial physician may be grouped, broadly, as follows: Purely medical services, such as advice and treatment; clinical laboratory and field research work; factory hygiene and sanitation; other allied activities, such as industrial housing, recreation, nutrition, and educational. The employment of trained nurses to take charge of works' dispensaries and to visit sick employees is growing in favour in most countries, Australia included. In England and America the provision of dental treatment is becoming more and more

popular and an innovation in America is the employment of trained dieticians to educate the workers in the nutritive value of foods. A feature in one of the larger works in England is the introduction of periodical medical examination of children up to the age of sixteen years. In Australia to-day there is, unfortunately, a suspicion on the part of organized labour as to the objects of industrial medical service and this difficulty must be overcome.

Accident Prevention.

The National Safety Council of America has done very valuable work in reducing the number of industrial accidents and this has been accomplished in a large measure by the stimulation of the appointment of safety committees, mostly composed of the workers, in the individual works. It is a matter for congratulation that an Australian "Safety First Association" has recently been formed and one hopes that its activities will effect a marked reduction in the present high accident incidence of this continent.

Educational Facilities.

The American universities are devoting considerable attention to the subject of industrial medicine and special lectures and courses in industrial hygiene and occupational diseases are given at several of these institutions. These courses have been arranged to afford training facilities to those intending to act as industrial physicians, but as occupational diseases are by no means uncommon, their signs and symptoms should be known by every medical practitioner and studied by every medical student. The Australian universities might with benefit to the community give similar courses on these subjects to the undergraduates and include them in the Diploma of Public Health curriculum.

Health Section of the International Labour Office.

The Health Section of the International Labour Office is doing work of supreme importance to all interested in industrial medicine. This Section has been created to deal with all questions connected with industrial hygiene, including comparison and coordination of the legislative provisions of different countries. It also undertakes general or special inquiries on unhealthy occupations. Notes on industrial hygiene prepared by the Health Section appear regularly in the *International Labour Review*, the monthly magazine of the International Labour Office, and bibliographical notes are published from time to time. This office has published several studies on industrial hygiene.

Division of Industrial Hygiene, Commonwealth Department of Health.

This Division is acting as a liaison body with the Health Section of the International Labour Office. Through its knowledge of Australian labour legislation and industrial conditions it is able to afford all the necessary information required by the central body and at the same time inform those interested in industrial medicine of the advancements made in other countries. It offers to Governments and private industries a consulting service on any matters relating to industrial medicine and is prepared on request to make surveys of industrial establishments with the view to the detection of unhealthy influences and to suggesting measures for the prevention or minimisation of these influences. In addition researches are being carried on into some of the numerous industrial health problems.

Conclusion.

In conclusion it may be said that the economic loss resulting from the illness of wage earners is enormous. It is no exaggeration to say that disabling illness is responsible for the loss of six days per worker *per annum* or, if one considers that there are at least 1,500,000 persons gainfully employed in Australia, a total loss of at least 9,000,000 working days *per annum*. A saving of even one-tenth of this by the adoption of more scientific methods of disease control would more than repay the expenditure involved.

COLOUR TESTING.

By G. H. Taylor, L.R.C.P., L.R.C.S. (Edinburgh),
Medical Officer, New South Wales Government Railways and Tramways.

As my experience of colour testing is practically confined to my service as a Railway Medical Officer, a period of nearly sixteen years, my remarks will be founded upon that experience.

The evolution in the method of colour testing in this State is instructive. In 1886 a test for colour vision consisting of coloured wools was introduced, not Holmgren's. When the Railway Commissioners took office in 1888, the then Chief Commissioner (the late Mr. E. M. G. Eddy), who had been an officer of the London and North Western Railway, introduced as a test for colour and form vision a card on which were printed four colours, red, green, yellow and blue. In the centre of the card were a number of black dots to be used for testing form vision. The examinee was placed at a distance of four and a half metres (fifteen feet) from the card and was asked to name two colours, the remaining colours being covered by a piece of cardboard. In 1892 the British Board of Trade forwarded for the information of the directors of the various British railways a copy of the report of the Committee appointed by the Council of the Royal Society (Lord Rayleigh's Committee) and asked for their (the director's) criticism. The report presented to Parliament by the Board of Trade in 1894 shows that the Secretary of the Lancashire and Yorkshire Railway forwarded to the Board of Trade a "copy of a card which is used in the testing of this Company's servants in the matter of colour vision." The card which was reproduced in the report was identical with the one introduced in New South Wales in 1888. In the description and instructions printed in the Board of Trade report appears the following: "Modified after the regulations issued from the Horse Guards by Professor Longmore in 1868." Incidentally the Secretary of the Lancashire and Yorkshire Railway in his letter to the Board of Trade stated: "We find that there are very few cases indeed of colour blindness, in fact during the last ten years only one or two men have been found deficient in this respect."

In 1902 my predecessor recommended "that the test for colour vision should be by means of coloured glasses as follows: red, green and purple, as used in signals, and

also a yellow glass. These were placed in a small frame having apertures about two and half inches in diameter, made in such a manner to admit of the glasses being changed by hand in order to prevent the possibility of their order being learnt." Before approving of this recommendation the Commissioners sought the advice of a Sydney ophthalmic surgeon who endorsed Dr. Woodward's recommendations and advised that the cards previously mentioned should be used as well as the coloured glasses, but that only one colour on the card should be shown at the same time. These two methods remained in operation until 1904. In that year the question of uniform standards for vision, colour, sense and hearing was considered by the Interstate Conference of Railway Commissioners and Holmgren's wool test and Dr. Williams' lantern test were adopted as the tests for colour sense. These tests were brought forward by the then Chairman of the Victorian Railway Commissioners (Mr. Thomas Tait) and were similar to those in use on the Canadian Pacific Railway of which railway Mr. Tait had been an officer prior to his appointment in Victoria. The introduction of these tests resulted in the discovery of several men with a defective colour sense. Eventually the Commissioners decided to replace the Holmgren test for men already in the service by a test which was "ability correctly to select from six shades each of red, green, purple and yellow wools." An examination of a large number of colour blind and colour normal persons by this wool method failed to disclose to the examiner any distinction between the colour efficient and the colour inefficient and it has long since been discontinued in this service. The Williams's lantern test was retained.

Some years of experience with Williams's lantern showed that, owing to the colours being exhibited in the one sequence, it was possible for a person with a defective colour sense who had been trained to an exact knowledge of his defect, to pass an experienced examiner as having normal colour sense, when the lantern was used alone. Alterations were, therefore, made in the Williams's lantern which permitted the examiner to vary the colours exposed, both as regards sequence and combination, as desired.

The Holmgren wool test was retained as the test for applicants for employment until 1915. During that time about 58,000 persons were examined and I was convinced that in a percentage of cases its findings were not correct. Its application was slow and tedious and it had an exhausting effect on the officers who conducted the examinations.

In 1915, on my recommendation, Stilling's plates were adopted and used in conjunction with the modified Williams's lantern as a test for colour sense for persons entering the service.

In 1922 the Interstate Conference of Commissioners adopted Stilling's plates together with the Edridge Green or modified Williams's lantern as the test for colour sense on all Australian railways.

I am satisfied that a trained and observant colour blind person may remain undetected in one examination by the modified Williams's lantern or the Edridge Green lantern, but I am also satisfied that a person who can pass the modified Williams's lantern, the colours in which are restricted to red, green and white, without error, and who also satisfies a trained examiner that he is efficient in 1, 2, 3, 4, 5, and 8 of Stilling's plates, although he may still have an undetected defect, is safe as a railway man.

What follows is an example of the unconscious variation through experience in the minds of the same examiners in regard to efficiency in colour testing by the present method. Out of many thousands of men examined for entry into the Railway Service the percentage of colour failures since 1916 is set out in Table I.

TABLE I.

Year	Failed Stilling and Lantern	Passed Stilling, Failed Lantern	Failed Stilling Only	Total
1916	6.56	2.31	0.04	8.91
1917	5.26	1.15	0.13	6.54
1918	5.46	1.12	0.08	6.66
1919	4.95	0.93	0.08	5.96
1920	5.20	0.16	0.02	5.38
1921	4.89	0.36	0.04	5.29
1922	4.37	0.32	Nil	4.69

It thus appears that 4.70 may be regarded as the percentage of failures in men entering the Service through colour defect.